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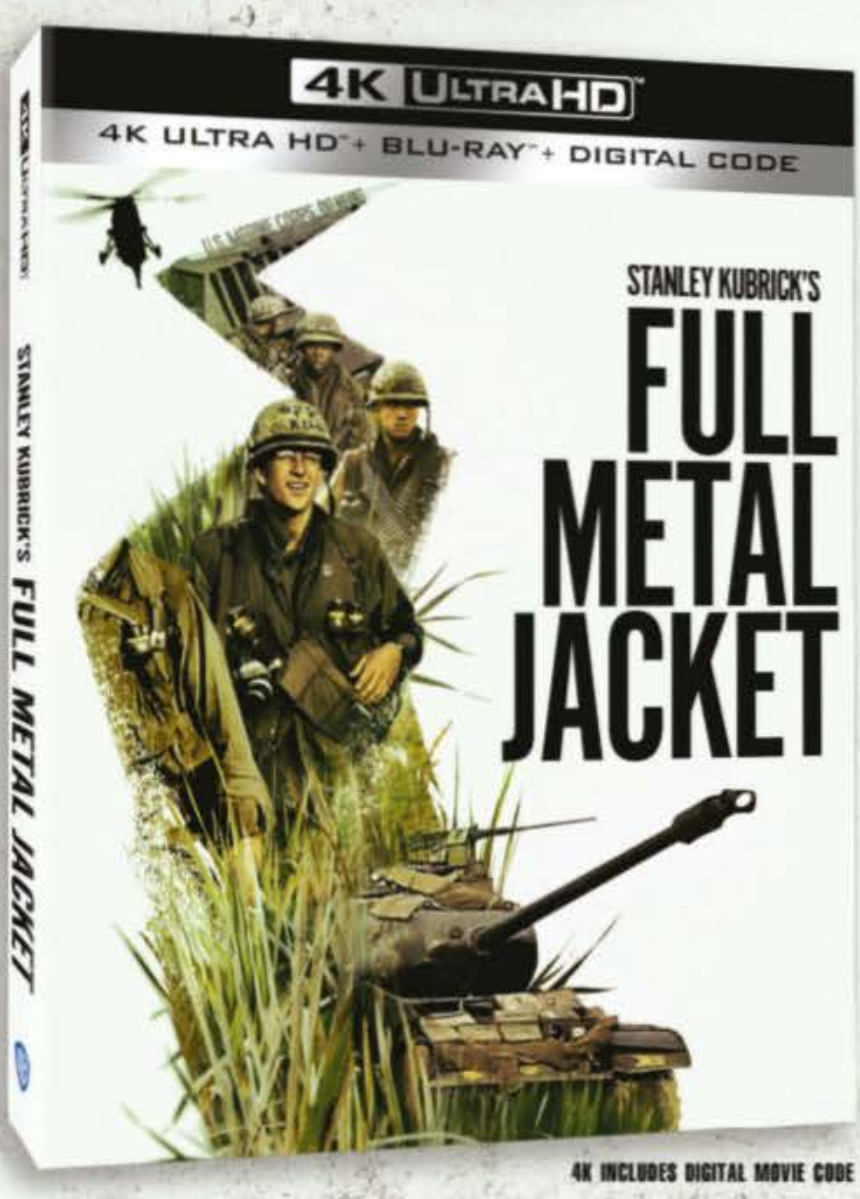

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Zak Storey

STATISTICAL NUMBER CRUNCHING

THERE'S NOTHING WE like more at *Maximum PC* than being presented with a challenge—a concept, a build idea, something grand that requires us to think a little more outside of the box than usual, and over the last few weeks we've received two interesting queries from the likes of Vincent Thompson and Tali Kadosh with exactly that. Just how do you go about building a good system for a data scientist or someone interested in statistical analysis? Well this issue I set Christian to task to build exactly that, looking at the parts and process required to build the perfect number-crunching rig for all of your at-home, stat-based desires. We originally set out to build this PC for a price point of around $3,000 to $4,000, but we've overshot that somewhat, so we're also recommending where exactly you can save some cash with the build, and just how that might affect performance.

For our second system of the month, we've gone with something a bit "different." This is a system I've wanted to build for some time, and it's based around a tiny little ITX case (if you can call it a case) from a small company called Hydra in Italy. Now this is a single sheet of folded and powder-coated steel, with aluminum feet and an incredibly simplistic design. It comes in at just under $111 without tax and shipping, and honestly is one of the most interesting cases we've had in for a long while. In fact it's very much an open-air chassis, designed for air-cooling first and foremost. For this build we've gone with a fairly mid to high-end gaming spec; it features an Intel Core i5-10600K, 16GB of DDR4, and a 2TB Samsung 970 Evo Plus. However, the GPU powering it is an Nvidia RTX 2080 Super, making it ideal for anyone looking to dive into those pixelated worlds in their spare time. That said, it's a super-easy build, and if you're looking to craft something for a home office that looks epic, and you're not interested in the graphical horsepower or vast quantities of storage that this build has, simply remove the GPU and downgrade the SSD to a 500GB Samsung 970 Evo to save you $1,074 from the overall price (for a total of $1,342), and that'll still leave you with a super-fast, easy-to-clean, well-equipped desktop machine.

For our other features this issue, first up we're delving into the extreme world of exotic overclocking, with a deep-dive into how you can become a world-record breaker yourself, and push your silicon to the absolute limits of its performance with the help of some liquid nitrogen. We've also recruited Neil Mohr of *Linux Format* fame to divulge all of his worldly knowledge on why exactly Apple has ditched Intel for ARM, and what that might mean for us PC desktop enthusiasts in the future.

We also have an extensive swathe of reviews and tutorials, including the third installment of our WordPress series, and a fully updated blueprints section. I do hope you enjoy the latest issue of *Maximum PC*! And as always, stay safe out there.

Zak Storey is Maximum PC's *editor and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.*

↘ submit your questions to: comments@maximumpc.com

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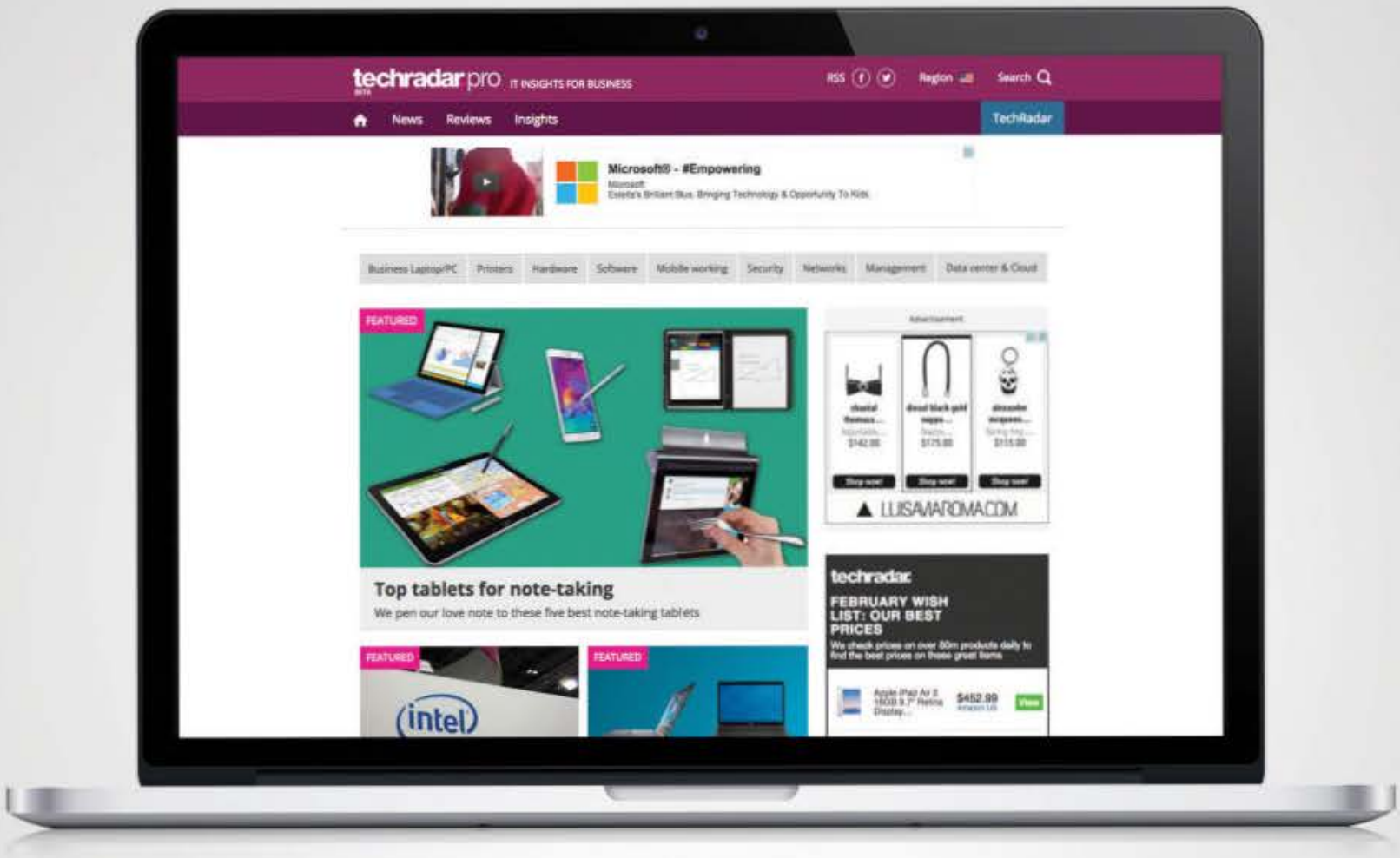

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THE NEWS

Ryzen 4000 Series Reaches The Desktop

Now you can go AMD with integrated graphics

AMD CONTINUES its quest to reach every segment of the PC market with the Ryzen Zen 2 by releasing a new set of processors aimed at one of the few remaining targets: OEM desktops with integrated graphics. AMD's current crop of 3000-series chips don't carry graphics, putting them at a disadvantage against Intel's. The 4000-series offerings are essentially desktop versions of the 4000-series laptop parts, complete with the integrated Radeon GPUs, code-name Renoir. This means it doesn't follow the 3000-series Chiplet design: It's a single slice of silicon, and it lacks PCIe 4.0. AMD claims them as the world's first and most advanced 7nm x86 desktop processors with integrated graphics. It also boasts of enthusiast-level performance for gaming, with smooth 1080p gaming "right out of the box."

The main consumer version comes in two groups. There is a trio of 65W TDP chips: The Ryzen 7 4700G, Ryzen 5 4600G, and Ryzen 3 4300G. The top chip has eight processor cores, eight graphics cores, and a base clock of 3.6GHz, a maximum boost of 4.4GHz, and a GPU speed of 2.1GHz. The 4600G has six processor cores and seven graphics cores, a base clock of 3.7GHz, with a boost of 4.2GHz. The 4300G has four processor cores and six graphics cores, a base clock of 3.8GHz, and a boost of 4.0GHz.

Then we have a similar trio of 35W TDP chips that are signified by an "E" suffix. These have the same core counts, but run a little slower. The 4700GE has a base clock of 3.1GHZ—500MHz slower than its big brother. The 4600GE loses 400MHz, and the 4300GE just 300GHz. There appears to be relatively little sacrifice to cut 30W from the TDP, although AMD's bizarre calculations for TDP are a law unto themselves. Lastly we have a corresponding range of 4000 "Pro" versions, which add various business-orientated security technologies such as Memory Guard, but are the same for cores and speeds.

As usual, AMD offered some comparisons with Intel's chips. It estimates that the 4700G is up 31 percent faster in multi-threaded performance against a Core i7-9700. More tellingly, it claims a graphical performance that is up to 202 percent faster, which even if only half true is impressive. The pricing is said to be aggressive, according to the usual round of leaks. Reportedly the 4000 is as overclockable as any AMD chip, and all come unlocked. A Ryzen 7 4700G has already been seen running at over 4.8GHz on all cores.

Want one? Well for now the new chips are for OEMs and System Integrators only, so you'll have to buy a whole system. However, this won't last for ever—AMD hinted as much by stating "do not take today's announcement of the 4000 series for pre-built desktops as something that we are not doing for consumer motherboards." There will be APUs for 400 and 500-series motherboards soon. We expect the first 4000-powered desktops to arrive this fall, from Lenovo, HP, Dell, and the usual OEM suspects.

These chips are an important release for AMD, as it pitches the Ryzen right into the heart of the mass-market. It has been building APUs for years, but with the 4000 series you can at last have one with eight cores—previously, going AMD meant you were limited to four at the most. AMD has done nicely in the more specialist markets, but reaching the big sales numbers means going OEM, which is five times bigger than the "enthusiast" sector.

AMD is certainly having a good year. Its second-quarter revenue hit $1.93 billion, 23 percent better than last year's figures. The third quarter promises to be even better, with a projected rise of 42 percent. Strong sales of laptop chips have helped (revenues have doubled thanks to the 4000 series), but it's still the EPYC server chips that are drawing in the big profits. It is doing well, but it's still a long way from Intel's market share; it has (roughly) about 15 percent of the x86 market. If the 4000 series makes even moderate headway in the sizable OEM, it will eat into Intel's numbers. **–CL**

> AMD is certainly having a good year. Its second-quarter revenue hit $1.93 billion.

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PC GAMER

DDR5 FINALLY FORMALIZED

SPEEDS START AT 4800MT/S, WITH DUAL CHANNELS AND VRMS ON EACH MODULE

JEDEC, the Joint Electron Device Engineering Council, has finalized the specifications for DDR5 memory. This 5th generation of DDR was originally scheduled for 2018, and Hynix built the first SIMMs that year, and we've have a number of "preliminary" DDR5 modules since. Now it's all official. The maximum die density has jumped from 16Gbit to 64Gbit, and the maximum capacity to 128GB. Each DIMM has two 32-bit memory channels, instead of one 64-bit one, increasing the burst length. Memory voltage has dropped to 1.1V from 1.2V. A big change is the use of on-board voltage regulators; the module takes a straight 5V power supply from the mobo. Each module gets a VRM tuned to its requirements, rather than having a mobo set of VRMs that have to handle every eventuality.

DDR5 is expected to appear first as DDR5-4800, with DDR5-6400 following. The server rooms will be the first customers, using LRDIMMs of up to 2TB, with consumer rigs joining the party late next year at the earliest. **–CL**

MASSIVE TWITTER HACK

Famous people suddenly offering free Bitcoin on Twitter

IN AN EMBARRASSING security breach for Twitter, around 130 high-profile accounts were hacked, and tweets from these accounts promised to double any Bitcoin you sent them. The scam managed to net about $115,000 of Bitcoin from the credulous before Twitter closed it down. The company called the scam a "coordinated social engineering attack."

The number of targeted accounts hit has led to speculation that the perpetrators had help. A phishing trip may break into one account, but to gain access to so many at once isn't easy without someone on the inside. One anonymous source who contacted the press claiming to be part of the attack said that the hackers had paid a Twitter employee for account access. Along with the fairly crude attempt to solicit money, some compromised accounts have also lost private direct messages. The scam has been called the "worst hack of a major social media platform yet." It highlights how Twitter, which can reach millions in seconds, is vulnerable to misuse. Three people have been arrested for their part in the attack. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

MATERIAL YOU CAN'T CUT
Researchers have developed a synthetic material called Proteus that is almost impossible to cut.

FLIGHT SIMULATOR DVD
You can buy Microsoft's *Flight Simulator 2020* in physical form, and it takes 10 DVDs to do it, including 90GB of maps.

CHEAPER WHEELS
Apple wants $699 for a set of wheels for Mac Pro. 3rd-party sets appeared for $500 less.

TRAGEDIES

BYE, TOSHIBA LAPTOPS
After 35 years and some of the best laptops of the 90s, Toshiba is quitting the PC business.

EXCEL BEATS SCIENTISTS
After years of Excel misreading gene names as dates, genetic scientists have resorted to re-naming 27 human genes.

BADPOWER FIRES
The firmware in fast chargers could be vulnerable to hacking, potentially turning devices being charged into firebombs.

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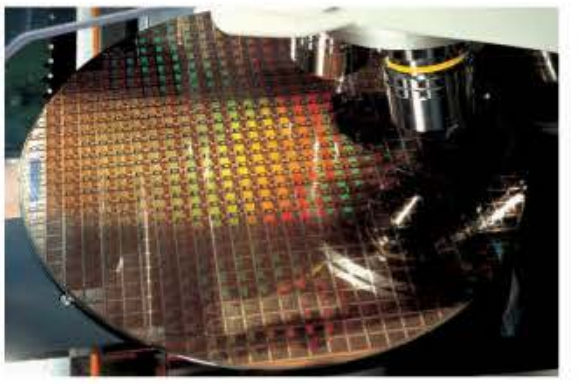

INTEL DELAYS 7NM CHIPS, AGAIN

And it may need help building them

INTEL'S PROBLEM going beyond the 14nm Skylake processor to 7nm parts shows no sign of ending, as the company has pushed the release date back another six months, to late 2022, or early 2023. The project is now a full year behind schedule. Apparently the yield rates are terrible, although Intel says that it has analyzed the situation and that there is no "fundamental roadblock." It can fix this. It also said that it has "contingency plans." This means more stress on 10nm parts (lackluster, and way behind schedule too), and the "backport" of 10nm designs to 14nm for the desktop.

Intel's CEO, Bob Swan, said that the company will be "pretty pragmatic" about who makes its chips in the future. If Intel can't get its own fabrication plants working smoothly at 7nm, it will have to go elsewhere. Intel has used other manufacturers before, but only for specific minor parts. If its plants can no longer handle the heavy lifting, this is not good news. Meanwhile, TSMC has started making 5nm parts, and has plans for 3nm by 2023. The announcement caused a significant jitter in stock prices—within hours Intel stock dropped 16%, and TSMC (makers of AMD's 7nm Ryzens) gained 10%.

Before we get too downbeat, this is Intel, a company with massive resources, superb engineers, and world-class technologies. Its numbers are still solid, including a highly profitable data-center business. It remains to be seen if it can fix its foundries. The danger is that if it falls too far behind then the manufacturing side will begin to drag.

Within Intel some important, and expensive, decisions need to be made. Does it maintain a top-level manufacturing ability or not? Its previous success has been built around being an IDM—integrated device manufacturer—going from design right through to final sale on its own. Intel won't be in any hurry to change that. Being pragmatic about exactly who makes what can only help in this difficult transition. **–CL**

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THE LIST

THE MOST BANDWIDTH-GUZZLING APPS

8 APPLE MUSIC 1 GB/HR

British company Uswitch recently revealed which apps are chowing down on the most bandwidth in homes under lockdown. Apple Music clocks in at number eight.

7 TIDAL 1.27 GB/HR

Jay-Z's high-definition music-streaming service certainly demands more bandwidth than the likes of Spotify. Lossless audio and music videos are largely responsible for this.

6 DISNEY PLUS 1.5 GB/HR

Fun fact: Disney's new-on-the-block streaming platform uses 50% more bandwidth on average than Netflix, and 87.5% more than Amazon Prime Video.

5 IHEART RADIO 1.65 GB/HR

Podcasts and live radio shows have evidently been popular in lockdown, and iHeartRadio (formerly known as Clear Channel) has been hogging the Wi-Fi a bit.

4 SOUNDCLOUD 1.65 GB/HR

More complex features like embedded widgets and downloads, as opposed to streaming, means that SoundCloud is a bandwidth-intensive way to listen to music.

3 NVIDIA GEFORCE NOW 2 GB/HR

Game streaming is naturally a data-heavy process, so it should be unsurprising that Nvidia's hosted-environment gaming platform gulps down bandwidth like candy.

2 FUBOTV 3 GB/HR

Sports-focused fuboTV offers dual streaming and Cloud DVR storage for high-definition livestreams of sporting events. And wow, it's hungry for data.

1 GOOGLE STADIA 4.5 GB/HR

Of course Stadia gets the number-one spot. Google's 4K-capable game-streaming platform is an absolute monster when it comes to bandwidth use, so we're not even remotely surprised.

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HEAD TO

BY **CHRISTIAN GUYTON**

Intel Core i9-10980XE vs AMD Threadripper 3970X

It's a flagship showdown! Intel and AMD both have ridiculously expensive desktop CPUs to offer, but which is better? In the Blue corner, we've got the Core i9-10980XE, a creative powerhouse built on Intel's 14nm architecture. In the Red corner, it's the Threadripper 3970X, a monster of a chip with 32 cores and AMD's 7nm FinFET process. Zen 2 microarchitecture makes the AMD chip more advanced in some areas, but Intel's chip has its own benefits too.

ROUND 1

Value

At first glance, the Threadripper dominates here. The i9-10980XE is currently priced at over $2,000, despite previous sales at closer to $1,000. The price will no doubt drop again, but the 3970X is available at the time of writing for $1,899.99, placing it far below the 10980XE in terms of price-per-core. The Threadripper also has higher base memory support and more cache memory, despite its lower price.

However, the Intel chip's RRP was in fact dropped to $979. One imagines that the high prices we're seeing right now could be tied to COVID-triggered production issues, or general stock shortages, or simply a price hike for Intel to capitalize on lockdown demand. If we consider that sub-grand price point, the 10980XE looks a lot more reasonable. The 3970X, on the other hand, is a newer chip that isn't likely to see a significant price drop anytime soon. It looks practically affordable next to the comically expensive 3990X, which is currently priced at $4,170, but it's still a crazy amount of money to spend on a processor. Neither of these CPUs are truly good value, but nothing in the HEDT sphere is right now. It's tricky, but assuming you actually can find a 10980XE for closer to $1,000, Intel wins.

Winner: **Core i9-10980XE**

ROUND 2

Performance

We'll break this down into professional workloads and gaming workloads. Both chips excel in each area; when you're spending this much money, you'd expect as much. The Threadripper has a clear edge in productivity tasks, beating the Intel competitor in just about every area. 3D rendering, video encoding, file compression, you name it: the 3970X is a beast with its 64 threads. The 10980XE might perform better in specific benchmarks, but on the whole the Threadripper is simply more powerful.

Gaming is a different story. Yes, the 3970X is still better, but it's a far less dominant lead. Intel actually demonstrates better performance in some games when using the same GPU, and the AMD processor generally doesn't provide more than a few fps extra in most titles. Of course, neither of these are CPUs anyone should be buying exclusively for gaming—direct your funds towards a powerful GPU instead for that—but plenty of systems are multipurpose. If you're a videographer, why keep two powerful PCs around for work and gaming, when one could handle the lot? And in such a system, the Threadripper is going to win out over Intel's "Extreme Edition" chip. Round 2 goes to AMD, although it's a close one.

Winner: **Threadripper 3970X**

ROUND 3

Features

Both of these processors have a lot to offer. Both provide quad-channel memory support up to 256GB, and both utilize proprietary technology to double up on threads (that's simultaneous multi-threading for AMD, and Hyper-Threading for Intel). The Threadripper offers EEC memory support, unlike the XE, but this is a niche benefit; EEC memory is often slower than conventional DDR4, and isn't widely available for individual consumers.

The 3970X has one big point in its favor against the 10980XE, and that's PCIe 4.0 support. That means it can interface with ultra-fast 4th-gen M.2 SSDs, and the 3970X can also handle more active PCIe lanes: 64 as opposed to 48 on the Intel chip. The 10980XE has superior overclocking potential, but these are both professional-grade workstation CPUs, so anything beyond auto-overclocking is risky. Intel Turbo Boost and Deep Learning Boost are welcome additions, but like EEC RAM support on the 3970X, the latter is niche.

If you're confident the Intel chip better suits your workloads it'll do great, but the Threadripper offers wide-reaching benefits. The 3970X's massive amount of onboard memory (144MB cache) makes it awesome at multitasking too.

Winner: **Threadripper 3970X**

HEAD

ROUND 4

Efficiency

Okay, AMD loses this round. Sorry to burst your bubble, Team Red, but the Threadripper 3970X has a TDP of 280W, as opposed to the i9-10980XE's comparatively subtle 165W. Yes, that's still a lot, but the 3970X draws so much power it could never hope to win this round. Use of this processor mandates a high-powered PSU, which will cost more initially and over time. The 10980XE is no slouch when it comes to power consumption (note that TDP and power use are only indirectly connected), but a 600W power supply should do the job.

It's not just about power, either. The Threadripper generates a lot more heat during heavy use than the 10980XE, effectively forcing you to spring for liquid cooling, be that a high-end AIO or a custom loop. The mounting bracket for coolers hasn't changed from TR4, used by 1st and 2nd-gen Threadripper CPUs, but many coolers don't come with an sTRX4-compatible bracket, or require one to be purchased separately. The 10980XE's lower heat generation and LGA 2066 socket allow for a wider range of possible coolers, and demonstrates better power and heat efficiency in mixed workloads anyway. It's a smaller chip with fewer cores, so this was hardly a surprising result. Intel wins.

Winner: **Core i9-10980XE**

ROUND 5

Professional support

This category is an important one when discussing HEDT parts. These chips are primarily used by enthusiasts and industry professionals, be they creatives or number-crunchers, so manufacturer support is vital. Both processors offer three-year limited warranties, but what about customer service?

We took to consumer feedback sites to gauge the general response, since we typically deal with tech companies through their corporate PR teams. While both AMD and Intel theoretically offer full refund-or-replace services for faulty parts, anyone who has found a component dead on arrival will be familiar with the murky underbelly of RMA support. It seems from customer reviews that experiences are strongly mixed for both companies. One website listed aggregated user scores for Intel and AMD at 3.0 and 3.1 respectively. However, a read-through of the reviews under Intel revealed a lot of people angrier at processor performance than customer service, whereas we found no end of ticked-off AMD customers struggling to return dodgy parts.

It's a close one, but we're going to give the win to Intel. They've got more cash to throw around and more experience when it comes to consumer CPUs.

Winner: **Core i9-10980XE**

And the winner is...

The Intel Core i9-10980XE takes this one, but only by a hair. There's a pretty big caveat hanging over this victory, though: If you can't find a 10980XE for less than $1,000, the Threadripper 3970X becomes the superior choice.

Both chips have their benefits. The huge generational price drop on the 10980XE was unexpected—welcome for sure but evidently not reliable, as some certified Intel retailers are currently asking for as much as $2,200. Neither processor comes with a cooling solution included, which is unsurprising given that more powerful aftermarket cooling is a must-have here. Both can dominate in multi-core and single-core workloads, with a slight edge to Intel in single-core performance and a heavy lead for AMD in multi-core tasks. But 32 cores will do that; it's not a failing on the XE's part, the Threadripper merely exists on a higher level of physical design. It's far larger than the Intel CPU, and demands a pricey new TRX40 motherboard for full operational capability. Intel wins today, but secretly? This might be a tie.

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DOCTOR

THIS MONTH THE DOCTOR TACKLES...

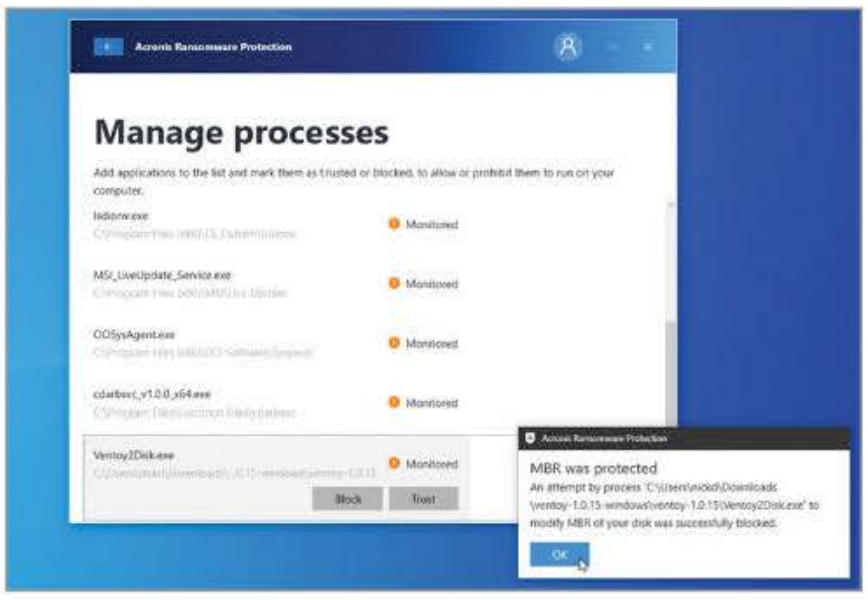
> Test For Corrupt RAM
> Ventoy Gets Blocked
> Laptop Won't Boot

Random Freeze Part 2

Hi Doc, regarding my earlier email about random freezes, by the time you responded, the whole PC had broken down: When I power on, the fans light up, and so does the RGB, but nothing else lights up, and the ROG logo does not light up when the machine is off. It was supposed to be on all the time.

About the corrupt RAM, I have seen several blue screens with the stop codes "SYSTEM_THREAD_NOT_HANDLED" and some other memory management error. I mainly play *Terraria* and *Geometry Dash* on the PC. I could try buying a new set of RAM from a different manufacturer, or is it the mobo? Finally, to answer your earlier question, I have a 750W PSU. **–Rector-Stingray**

THE DOCTOR RESPONDS: At first glance, the blue screen errors would suggest that your RAM is the problem, but it might also point to a failing drive (or even just a drive that needs a good run-through with the Disk Check tool). The fact your PC appears to have "broken down" would point towards the RAM, processor, or motherboard, though —key components re-quired for the PC to get as far as the POST screen. The Doc can't give you a definitive answer as to which is the culprit, but he can show you the steps he'd follow in your position.


Acronis Ransomware Protection
Manage processes
Add applications to the list and mark them as trusted or blocked, to allow or prohibit them to run on your computer.
Monitored
Block
Trust
MBR was protected
OK

Instruct Acronis Ransomware to trust Ventoy.

First, the cheapest and easiest component to test is the RAM—and the blue-screen errors would suggest this is the best place to start. If your PC could get beyond the POST screen, we'd recommend you create a Memtest86 bootable flash drive (www.memtest86.com) on another PC, then boot from that to grill your RAM and hopefully confirm the diagnosis with test failures.

Assuming you can't even get as far as the POST, you may still have one quick diagnosis option left. If you purchased your RAM as a pair of 4GB sticks, try removing one and seeing if your PC will now boot; if it doesn't, try the other. With a bit of luck, only one stick will be corrupt, and you'll be able to boot using the working stick. If so, your solution would be simple: Replace the RAM with sticks known to be compatible with your mobo (there's a comprehensive list at https://bit.ly/MPCoctRAM).

If you only have one stick of RAM, or trying the above test fails to work, you'll have to make a decision about which parts to swap out: The Doc would probably order more RAM first in the knowledge that if it doesn't fix the problem, you could either return the RAM or keep it to boost your PC's memory later.

One final thing: Your motherboard should issue a short beep when it starts—if you've never heard this, then have you connected it to the case's system warning speaker (consult page 1-20 of your mobo manual for details)? Once connected, you should hear a series of beeps at startup—one continuous beep followed by several short beeps: Two indicates memory failure, three no monitor detected, four for hardware component failure, which would indicate a problem with the mobo or processor.

If you decide to replace the mobo, a direct swap is the simplest option because your current Windows installation won't be affected, and you can be up and running again quickly. Hopefully, you'll still be under the manufacturer's warranty, so RMA it.

Tame Default Apps

I have a pet peeve against Microsoft. Seems that every update, the default apps for specific file extensions get changed to what they want and totally ignore what I want them to be. Specifically, I mean HTM, HTML, and PDF. Can you

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↘ submit your questions to: doctor@maximumpc.com

suggest a way, hopefully via a script, to set the defaults to the ones I want? **–Bad Big Dad**

THE DOCTOR RESPONDS: The Doc shares your pain. Part of the problem is down to the fact that Windows often leaps in when older programs attempt to grab the file associations—this behavior has been blocked since Windows 8 (allegedly for security reasons), and when Windows detects this, it moves swiftly to reset the defaults back to its own choices. If you're lucky, the next time you double-click a file of that type you'll be given the opportunity to make your choice of app from the drop-down menu, but if not, you've got to right-click the file and choose "Open with → Choose another app" to set it to your choice of program again.

Workarounds have been developed that tweak the Registry or run command-line tools, but tend to break from one version of Windows 10 to the next. Another trick that might work is to remove the Microsoft apps that Windows tries to revert to: Photos, Groove Music, Films & TV, Edge, and so on (basically, the option marked as "Recommended for Windows 10" under Default Apps). Not all can be removed through "Settings → Apps → Apps & Features" so you'll either need to Google for the commands required to manually remove them using PowerShell (for example, "Get-AppxPackage *photo* | Remove-AppxPackage" for Photos), or use a third-party uninstaller such as IObit Uninstaller Free (https://bit.ly/MPCOctiobit).

Screensaver Images

I have two unrelated questions: first, I have a collection of screensavers on discs from Second Nature Software. When I try to install these, it tries to validate from the website. The problem is that the company has been out of business for a long time and the website has been shut down. Is there any way to bypass the validation? Second, I keep getting requests to update Java. Is Java even needed any more? If needed, should I be installing the updates? **–Rich T**

Lazesoft can recover most Windows installations.

THE DOCTOR RESPONDS: Second Nature's screensaver is basically a slideshow of individual pictures, stored in its own proprietary SNX format to prevent people copying the files. If the pictures are visible on the CD as SNX files, then copy them across to a suitable folder on your hard drive.

Next, download and install the free sampler version of the Second Nature screensaver from a reputable site like https://downloads.cnet.com—Google "Second Nature Screen Saver" to locate a link.

During setup you'll be prompted to enter your email address—this goes nowhere, or you can add a fake email if you prefer. Once the program is installed, launch the tool from its Notification area taskbar icon, click the "Collections" button and choose "Create Collection." Make sure "Second Nature Images" is selected as the file type, then browse to the folder containing your SNX images and click "Select." The images should then be added to the program, which you can use as your screensaver.

As for Java, if you're sure you have no programs on your PC that require it to run, simply remove it. Should you later need it, go to www.java.com to download the latest version. If you plan on keeping it, make sure you install the latest updates for security reasons, as well as to fix bugs.

Ventoy Gets Blocked

I read your *Maximum PC* August article on Ventoy. I tried to install it but kept getting blocked by Acronis Ransomware. It said an attempt was being made to alter the MBR, and it blocked it. Not knowing enough, I respected it and pulled out of the install. Is this is an okay thing to happen? **–David Thiel**

THE DOCTOR RESPONDS: Ventoy is 100 percent legitimate. The problem here is Acronis Ransomware 2018, and the way it works to protect your PC from potential ransomware attacks. It doesn't rely on definition updates, but instead works on heuristics—namely, the behavior of your apps. It analyzes a program's actions, then compares it with a database of malicious behavior patterns—if it spots something that appears to match ransomware behavior it'll block it. Clearly Ventoy's attempts to modify your USB flash drive's MBR are misinterpreted as malicious.

You can instruct Acronis to trust Ventoy. Right-click the Acronis Taskbar Notification area icon and choose "Manage processes." Click "Add Application" to browse for and select "Ventoy2Disk.exe," which will automatically add it to the Trusted list (you can reverse this later by rolling over the program entry and clicking "Block"). Note, you'll need to repeat this every time you update Ventoy —make sure you do this before attempting to update your flash drive, or you may end up losing everything on the disk.

Non-booting Laptop

My daughter's Dell Inspiron N5040 laptop went from booting normally on the C drive to not booting at all and only showing an error message for drive X. As she no longer has the original Windows 7 installation discs, I tried the Lazesoft Recovery you've mentioned including its "final solution" but to no avail (message says it cannot fix it). What caused the HDD drive to change from C to X, and how do I fix this? **–Manuel A Trucco**

THE DOCTOR RESPONDS: When you boot into the recovery environment, it automatically assigns your Windows partition the X drive letter—so whatever problem your daughter has, that's not it. Before going forward, use Lazesoft Recovery's drive-imaging tools to make a failsafe backup of the drive's contents, so they're protected.

Assuming you've worked your way through the whole gamut of repair tools offered by Lazesoft with no success, your final option is to wipe the drive and start again from scratch. You can try restoring the laptop to factory defaults by selecting "Repair Your Computer" followed by "Dell Backup and Recovery." If this is missing, contact Dell directly to see if it's possible to purchase replacement recovery discs. Otherwise, you'll need to source your own copy of Windows 7 (or later) to install a fresh copy of Windows on the drive and start from scratch. Inspiron N5040 drivers are still available for download from Dell's support website should you need them.

Confused by Logging

Last issue, the Doc says to turn on logging by selecting "Logging" under options. I don't see that option in Open Hardware Monitor 0.9.5. What am I missing? **–Al Kraybill**

THE DOCTOR RESPONDS: Apologies, Al. The option is "Log sensors." Once switched on, the log file is stored in the "Open Hardware Monitor" folder.

© LAZESOFT

THE SCIENTIFIC METHOD

Need a number-crunching monster in order to work from home? We've got you covered

LET'S MAKE ONE THING CLEAR: We're not scientists. We're just slotting things into motherboards and praying it works, then writing funny words about it. We leave unraveling the mysteries of the universe to those smarter and better trained than us.

But we are pretty darn good at building PCs, and we've had requests from the more scientifically minded of our readership for a tutorial on how to build a powerful home PC designed to work on data analysis, statistical modelling, and any other scientific endeavor. With lockdowns in effect, many of us learned to work from home, which is fine and dandy if you're a writer but a problem if you need access to a lab. Those among you with a need to process huge datasets asked for a machine that could do that work from the comfort of your study, and here's our answer.

It's going to be expensive! We need two key things here: A truckload of RAM, and a high-end processor with as many cores as we can muster. This will enable our system to handle millions of points of data, making it capable of performing heavy-duty tasks such as training deep-learning models on consumer data, or analyzing massive amounts of data.

Graphics are an interesting point of debate when it comes to data-science systems. You need to know exactly what sort of programs you're going to be using on the machine—if you're running visualization or 3D-rendering software, a more powerful GPU is a must. If you need a system to just perform thousands of complex mathematical calculations, the GPU becomes less important. We'll be using a relatively high-end graphics card in this build, but our main focus is the CPU and memory.

What else do we need? Well, a pricey processor demands a pricey motherboard, and we also need a hefty power supply to keep this system running. Liquid cooling for our processor is also a must-have, and we'd advise that you do the same even if you want to spend less. If you're handling lots of data, you'll need plenty of storage, so we'll be using a high-speed M.2 SSD as our boot drive, and also including a larger HDD for secondary storage. To contain all this, we need a professional-looking PC case with good airflow and USB-C support for faster data transfers.

So it's darn expensive, like we said, but we'll go over some more affordable alternatives later on. This is essentially the best version of this machine we can build, but it's a build you can tailor to your needs; if it's overkill, cheaper components will work just fine. **–CHRISTIAN GUYTON**

BUILD IT
PG. 26

NUMBER-CRUNCHING MONSTER INGREDIENTS

PART		STREET PRICE
Case	**Phanteks Enthoo Pro 2 Closed Panel**	$130
Mobo	**MSI Creator TRX40 sTRX4**	$690
CPU	**AMD Threadripper 3970X**	$1,850
CPU Cooler	**Corsair iCue H115i RGB Pro XT**	$135
GPU	**MSI Radeon RX 5700 XT 8GB**	$400
Memory	**Corsair Vengeance RGB Pro 128GB** (8x16 GB) **DDR4-3200**	$690
PSU	**850W Corsair HX850 80+ Platinum**	$173
Boot Drive	**Sabrent Rocket 4.0 2TB**	$430
Storage Drive	**Seagate IronWolf Pro 4TB**	$140
Fans	3x **Noctua NF-A14 PWM 140mm**	$66
OS	**Windows 10 Pro**	$140
Total		**$4,844**

PRICES CORRECT AT THE TIME OF PRINTING

BUILD IT PG. 26

GPU $400

MSI RADEON RX 5700 XT 8GB

As we said, we're not going overboard with the GPU. If you already know that you need graphical power above all else, then you might want to consider a cheaper CPU paired with a more expensive graphics card, such as a GeForce RTX 2080 Super, or 2080 Ti. For our purposes here, though, the RX 5700 XT is a powerful mid-range card, easily capable of supporting multiple monitors and most visualization software. A last-minute price cut on the RX 5000 cards before their release means that they've always been great-value multipurpose GPUs, so the XT with 8GB of VRAM is the obvious logical choice for us here.

RAM $690

CORSAIR VENGEANCE RGB PRO 128 GB (8 X 16 GB) DDR4-3200

Corsair is a reliable choice when it comes to memory, not least when buying an eight-DIMM kit like this. That's eight different components that could go bust, and you're going to be grateful for that lengthy warranty if they do. They shouldn't, though. The Vengeance RGB Pro is an excellent option, and we can opt for the 8x16GB configuration thanks to our mobo's eight memory slots. RGB lighting isn't really needed here, but this memory is high-performance and good value for a 128GB kit. 3200MT/s memory speed and a CAS latency of 16 gives us plenty of speed to work with our powerful AMD processor, too.

© MSI, CORSAIR, PHANTEKS

CPU $1,850

AMD THREADRIPPER 3970X

Yowch! Yes, the price tag is a kick in the shins, but the Threadripper 3970X is undeniably one of the most powerful processors on the market right now. We didn't spring for the 64-core 3990X (it costs almost as much as this entire build!) but thanks to AMD's simultaneous multi-threading technology it still packs 64 threads. This is a formidable processor, and it does force the use of an expensive TRX40 motherboard, but this chunky chip will handle whatever you throw at it. You can't have a supercomputer in your house, but this might be the closest you can get.

MOTHERBOARD $690

MSI CREATOR TRX40 STRX4

Motherboards that can support 3rd-generation Threadripper processors don't come cheap, and the Creator TRX40 is no exception. It's an extremely reliable purchase, though, with high-quality power-phasing components that ensure your system runs smoothly even when you're drawing a ton of wattage for resource-intensive tasks. It also has the very best in connectivity, with Wi-Fi 6, 10G LAN, and high-speed USB-C support. The TRX40 chipset also means we've got access to the Threadripper 3970X's PCIe 4.0 support, allowing us to use a high-speed Gen4 M.2 drive. A thermal shield for that SSD and an extended heatpipe means that we shouldn't have to worry about our system temperatures, either.

CASE $130

PHANTEKS ENTHOO PRO 2 CLOSED PANEL

There's no need to spend too much on a case for a number-crunching system. The rise of PC gaming culture has seen PC cases erupt with all sorts of aesthetic features, from RGB fans to LED strips and tempered-glass panels. None of that nonsense here: The windowless model of the Enthoo Pro 2 from Phanteks is a case for the busy professional—a black metal tower with a performance airflow mesh on the front and plenty of internal space for our powerful system. There's also upgrade potential here, with bays for extra drives, tons of room for radiators and fans, and even space for an optional secondary ITX system using Phanteks's Revolt X power supply (sold separately, of course).

PSU $173

850W CORSAIR HX850 80+ PLATINUM

We're going to need a lot of power for this build, and good efficiency too, since it might need to remain switched on for extended periods of time while processing data. The Corsair HX850 gives us all the power we'll need, with a bit leftover for a GPU upgrade or some extra drives. An 80+ Platinum rating should guarantee between 89-92 percent energy efficiency, ensuring minimum waste, and the fully modular design will let us get rid of excess power cables. A 100,000-hour lifespan means that the HX850 is future-proofed, letting you keep crunching numbers for (in theory) over a decade of continuous operation. Don't do that, though: Let your system rest sometimes.

SSD $430

SABRENT ROCKET 4.0 2TB

We're still a bit limited when it comes to choices of PCIe 4.0 drive, especially at higher capacities. We've gone for a 2TB model, the Sabrent Rocket 4.0. It's not the cheapest option (TeamGroup's weird ceramic-plated Cardea C440 is a little bit cheaper, for example) but it's not the most expensive either, and it's reviewed well under the eyes of both critics and consumers. PCIe 4.0 unlocks beastly transfer speeds, with up to 5GB/s sequential reads. We're using the version without an included heat sink, since our motherboard has its own M.2 heat shields.

CPU COOLER $135

CORSAIR ICUE H115I RGB PRO XT

A high-quality AIO cooler is effectively a must-have for any Threadripper system. While air cooling is always an option, these chips are powerful and run hot, so liquid cooling is definitely the way to go. The H115i RGB Pro XT isn't cheap, but it offers best-in-class CPU cooling thanks to its 280mm radiator with dual maglev fans. The RGB lighting on the pump block isn't something we sought out, but Corsair's iCue software also allows for greater fan customization, including a nifty zero-RPM mode that shuts off the fans entirely when processor temperatures are low enough. Full sTR4 compatibility with a toolless swappable bracket is the last box we needed to tick.

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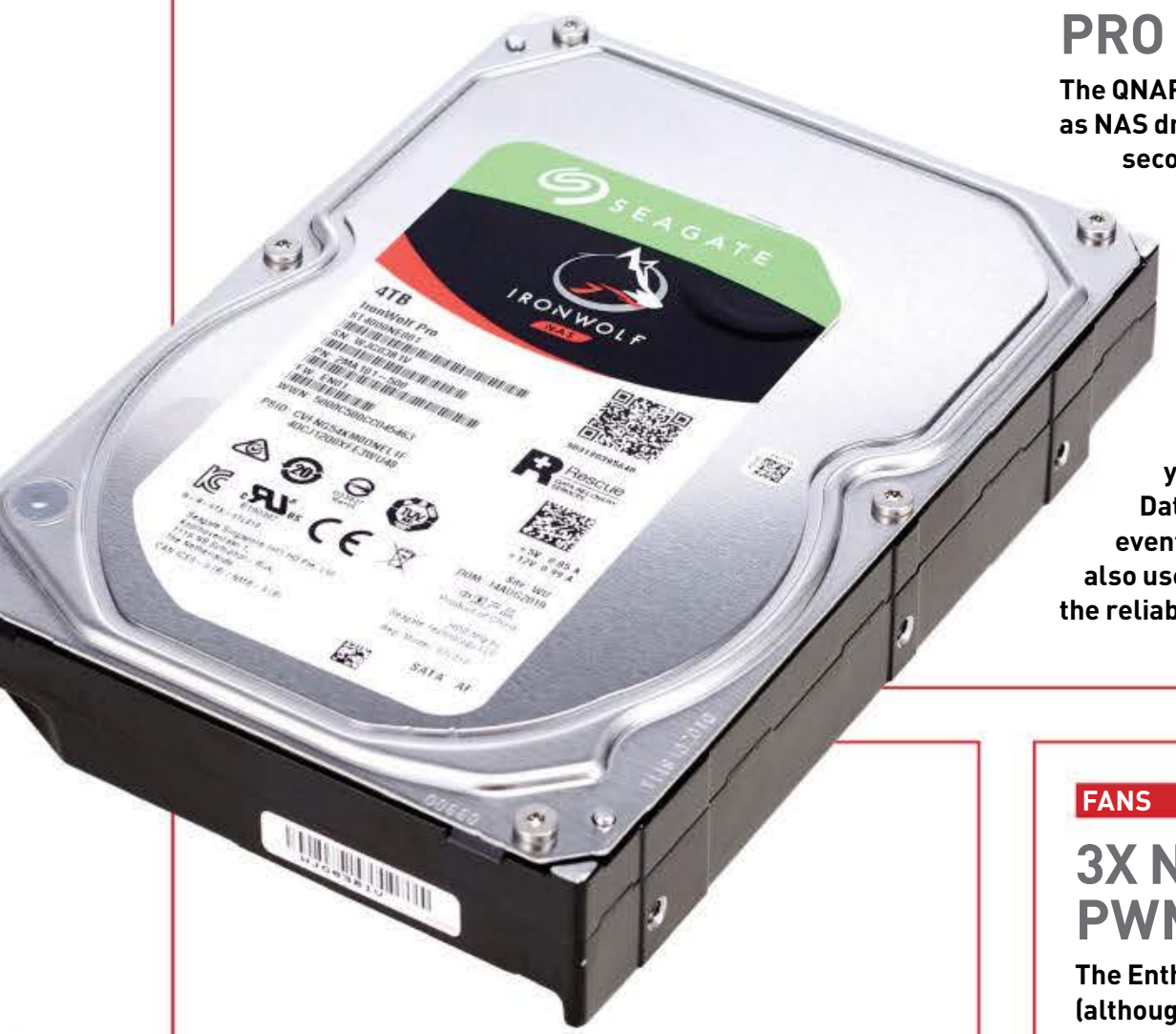
BUILD IT
PG. 26



HDD $140

SEAGATE IRONWOLF PRO 4TB

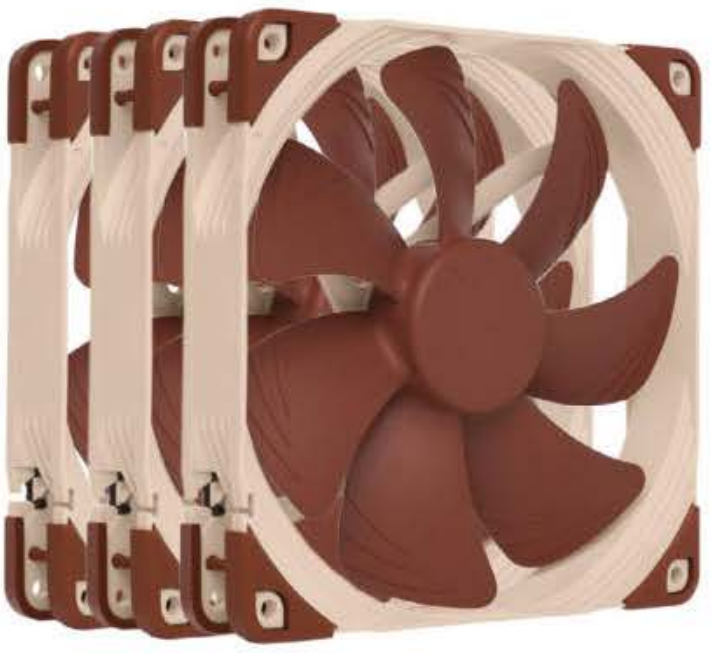
The QNAP-certified IronWolf Pro series are sold as NAS drives, but they work just fine for regular secondary storage as well. Four terabytes will give us plenty of storage to start with, and we've got room in our case for more HDDs if we decide to expand later on. 7,200 RPM and 128MB cache satisfy our hardware requirements, and the support from Seagate extends beyond the drive itself; purchasing an IronWolf Pro new nets you two years of the Rescue Recovery Data Plan, which provides support in the event of drive failure or data loss. You can also use IronWolf Health Management to check the reliability of your HDD.

© NOCTUA

FANS $66

3X NOCTUA NF-A14 PWM 140MML

The Enthoo Pro 2 doesn't come with any case fans (although you can buy it bundled with fans direct from Phanteks), so we've taken airflow into our own hands and added three of Noctua's award-winning NF-A14 PWM fans. These are premium 140mm fans. While we're using three, there's room in this build for four (or perhaps even five) alongside the AIO radiator. The NF-A14 fans are quiet but powerful, with a whopping six-year warranty that demonstrates Noctua's confidence in its products. The beige and brown color scheme might be upsetting to some, but have no fear: You can upgrade to the Chromax Black version for a few extra bucks if desired.



DATA-DRIVEN ASSEMBLY

Prepare your building area, making sure you have all the tools you need and plenty of space to work in. Not missing any crucial components? Then let's get started.

LENGTH OF TIME: **2–3 HOURS**
LEVEL OF DIFFICULTY: **EASY**

1 OPEN IT UP

BEFORE WE START PLUGGING things in and screwing things down, unbox the Enthoo Pro 2 case and strip it down so it's fully prepped for building in. The side panels come off easily via thumbscrews, and the exterior filters lift right off (either via plastic tracks or magnets), but the front panel can be a bit more challenging to remove. The push-pins on the back of the panel require quite a lot of force to release, but be careful not to damage the plastic. Underneath this panel (and its funky mesh window) is another dust filter, secured magnetically.

You'll need to install an HDD drive bay—the case should come with four—but we'll get to that later. You can leave the plastic blanking plates on the motherboard mounting boards in place for now, and the same goes for the screwed-on metal plate that can be removed to install a secondary ITX system. The PSU shroud includes a hinged cover that is secured with two extremely tight thumbscrews, but you can leave that closed for now too. The front I/O cables come pre-routed with handy Velcro strips but will need re-arranging later on, once the system is installed. One last thing you probably will want to remove is the SATA SSD mounting plates, purely to free up some cabling space behind the motherboard.

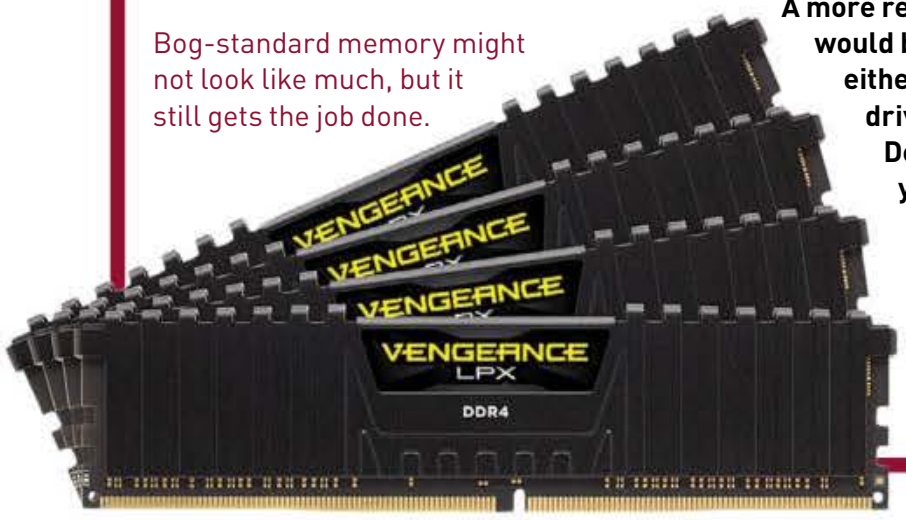
CUTTING BACK

Yes, we know: This machine is monstrously expensive. So let's talk about some more affordable alternatives. First up, you can eliminate RGB altogether and cut down to less memory; 32GB is a safe minimum for a system like this, but 64GB kits are also becoming more affordable. Sticking with Corsair, the Vengeance LPX is slightly more basic but a bit cheaper. Alternatively, you could opt for a lower-price brand, like G.Skill.

Making the change from AIO cooling to air cooling is always an option, but sTR4-compatible air coolers aren't common and tend to be fairly expensive. A more realistic money-saver would be to downgrade the SSD, either to a 3rd-generation M.2 drive or a 2.5-inch SATA. Depending on how often you need to move large files around, a SATA SSD could be a more sensible and cheaper alternative.

Of course, the big question here is the processor. The more cores, the better, but with SMT and Hyper-Threading becoming the norm, you don't necessarily have to spring for Threadripper to get your work done. The Ryzen 9 3900X is an excellent 12-core chip, but costs less than a quarter of the 3970X. Really though, any current-gen CPU from AMD or Intel with six cores or more will be at the very least capable of handling heavy data-analysis tasks. Avoiding Threadripper means you can save on your mobo too.

We didn't spend too much on our case, but we'd advise against cheaping out on the power supply for a system like this. Cheaper HDDs are an option if you don't mind lengthy copy times, and if you're really trying to squeeze every cent we'd recommend going for a case that comes with included fans.



Bog-standard memory might not look like much, but it still gets the job done.

© CORSAIR

2 BENEVOLENT CREATOR

LET'S UNBOX THIS MOTHERBOARD. The first thing you'll probably notice is the chunky PCIe card included in the box. This is an M.2 expander: The MSI Creator TRX40 already has three M.2 ports on the board itself, but you can plug this expansion card into one of the Creator's long PCIe slots to provide support for four more M.2 SSDs. Combined with the multiple HDD and SATA SSD drive bays in the Enthoo Pro 2, we've got nigh-unlimited potential for storage expansion here.

You'll need a torx key to open up the CPU socket , following the order of screws printed on the bracket. If you've bought your Creator TRX40 new, it'll have a plastic cover in place over the socket; this slides out easily once you've lifted up the bracket beneath the metal seal. Slide the Threadripper in its orange plastic casing and slip it into the bracket, then carefully push it back down into place and secure the screws again. Be sure not to over-tighten these; as long as the CPU doesn't wobble around in the socket at all, it's in position.

3 SOLID STATE DRIVING

NEXT UP IS OUR M.2 DRIVE. Normally we'd recommend installing the RAM at this point too, but we're going to leave that for later, since the eight sticks we're using might get in the way of fitting our cooler. The Sabrent Rocket 4.0, on the other hand, will be completely invisible once installed; this dinky drive comes in a lovely metallic case, and we'll be installing it underneath the motherboard's long, thin M.2 heat shield.

First, you'll need a small Phillips-head screwdriver to release the heat shield, loosening the tiny screw located at either end. These screws are fixed to the shield, so don't worry about losing them when removing it. The component you should worry about losing is the tiny M.2 screw that is used to secure the drive beneath the heat sink, but thankfully the Creator TRX40 comes with three of these. A mag-tip screwdriver is useful here. Remove the protective plastic strips on the two sticky thermal pads, and plug the drive into the longer slot. Secure it to the pre-fitted standoff using the M.2 screw, then replace the entire shield and screw it down. Again, don't over-tighten these screws.

4 FIXER UPPER

HELPFULLY, the Enthoo Pro 2 comes with a nifty little plastic screw box, which contains everything you'll need to secure the motherboard and other components (along with spare standoffs and the like). Our one somehow managed to open itself inside the case packaging and flooded us with mixed screws, although we actually took sadistic pleasure in carefully re-sorting all of them individually into their own little partitions.

Anyway... you'll need seven motherboard screws here (the smallest screws included with the case), so set those aside first, then lower your motherboard assembly carefully onto the mounting pegs inside the case. Make sure that the rear I/O is properly lined up, then secure the motherboard first by the central peg, then the corners, then finally the sides. You'll want your case on its side for this, but the Enthoo Pro 2 is undeniably bulky; if you don't have enough workspace on your table, it's okay to place the case on a non-carpeted floor and work sitting down instead. This can also be better for your back than standing and stooping down to work inside the case!

5 COOLING OFF

WITH OUR MOTHERBOARD in position, it's time to start adding more stuff to the case. The Enthoo Pro 2 doesn't come with any case fans as standard, so we've purchased three 140mm NF-A14 PWM premium fans from Noctua, one of our most trusted brands when it comes to air cooling. Two of these fans will be installed at the front of the case, and the third will go at the back. Make sure you install them all facing the same way, using the arrows on their edges to orient them correctly; air should be pulled in at the front of the case, then expelled through the rear and sides.

Each fan comes with four silver screws. Line them up with the slots on the front, and screw each fan in individually. The best course of action here is to loosely secure all four screws, then tighten them once the fan is mounted. We're fitting the two front fans near the top of the case, since we're not using an additional ITX system that would benefit more from another fan at the bottom. Before moving on to the next step, be sure to tuck the fan cables through behind the motherboard mounting plate—the radiator will obstruct access to the rear case fan's cable otherwise.

6 EXTENSION TENSION

HUH, LOOKS LIKE WE'VE GOT an XT graphics card and an XT cooler! We wonder what that means... a quick Google search claims that IBM coined the acronym for "extended technology" in 1983. This was just one year after Steven Spielberg rocked young minds across America with *E.T. the Extra-Terrestrial*, so we guess IBM probably didn't want to tread on the legendary director's toes.

The Corsair iCUE H115i RGB Pro XT is quite a mouthful to pronounce, but it's an excellent AIO cooler with Threadripper socket compatibility, which is a must-have. It comes with a small amount of thermal paste already on the heat plate, but you may want to add a tiny glob of extra paste given the size of the 3970X. The first thing you'll need to do here is pull off the pre-fitted bracket and replace it with the sTR4-compatible one; these snap on and off with a bit of force. Corsair's instruction booklets are very helpful in identifying which parts and screws you need. Be careful not to get thermal paste on your fingers while doing this!

7 RADIATOR BLUES

WITH THE RIGHT BRACKET installed, you're going to need eight long screws, four thumbscrews, eight radiator screws, eight washers, and four sTR4 standoffs. All of these are included with the cooler, and there's useful diagrams in the manual so you can ensure that you have the right screws for the job.

First, keep the case on its side and fit the four standoffs in the holes around the CPU socket. Attach the two 140mm fans before installing the radiator, using four long screws for each fan and checking that they will be filtering air upwards out of the case once the radiator is in position. Hold the radiator against the roof of the case, with the tubing towards the front, and secure it to the roof from the exterior using the radiator screws and washers (the washers keep the screws from moving under vibration and protect the case). Once the radiator is secure, you can align the pump over the standoffs and affix it using the four standoffs. Again, fit all four thumbscrews first, then tighten them one by one. Leave the pump and fan cables for now.

8 WHAM, BAM, THANK YOU RAM

WITH OUR AIO FITTED, it's time to install this massive amount of memory. Tuck the cooler's cables and tubes aside and open up all eight clasps, found on the end of each DIMM. One at a time (in no particular order, although we went left to right), push each stick of RAM down into the DIMM slot. You should hear a slight click at the claspless end, and a louder sound at the other end as the clasp locks into place. This should be an easy enough task, you simply have to do it eight times over. Check that all of the sticks are level at the end.

Once the memory is installed, we can turn our attention back to the AIO cabling. Stand the case upright, and feed all the cables through the rubber-necked hole beside the motherboard. Try to run these out and over the memory, so that it's comfortably away from the exposed radiator fans. Behind the motherboard, connect the fan cables to the two shrouded connectors from the pump. Separate the accessory power connector from the fan header cable, to feed the latter back through and plug it into the pump fan header in the corner of the motherboard.

9 VIDEO TECHNOLOGY

TO INSTALL THE GPU, you'll first need to remove two of the blanking plates secured at the rear of the case. Unbox the GPU and hold it over the desired PCIe slot (we used the third one away from the processor) to check which two plates will need to be removed, then grab a screwdriver and take 'em out. Put the screws to one side and open the clasp on the PCIe slot you're using, then carefully lower the GPU into place and push it down until it clicks and locks.

Once the GPU is in place, secure it using the two screws that you put aside earlier. The RX 5700 XT's metal backplate is a bit bulky, so tucking the two metal tabs on the lower end inside the case works better than clipping them outside the case. This isn't exactly ideal (the shape of the Enthoo Pro 2's rear side is part of the problem here), but as long as the screws are tight, then it shouldn't cause you any problems.

IN MEMORIAM

Memory is one of the most common issues when trying to get a fresh build up and running. But if your RAM is giving you the runaround, don't despair: There are many possible causes, and it's generally not too difficult to identify the issue. First of all, go to the motherboard manufacturer's website and double-check that your mobo definitely does support the capacity and frequency of memory you're using. If it does, check for a BIOS update; if you're running an outdated BIOS, that could be the source of your problems.

If neither of those are the issue, try testing each stick individually, or moving them to any open DIMM slots. Ensure that you're using the correct DIMMs; the motherboard manual should explain which slots to prioritize when installing memory. It's not always rational—common sense might dictate that slot A1 is the first one you'd want to use, but on the MSI Creator TRX40, we had to use A2, B2, and so on.

Often, your system will boot up just fine but fail to run the memory at full speed. This is particularly common with kits that run in excess of 3000MT/s: Many motherboards require an overclocking profile (in this case, A-XMP) to run high-frequency memory. You can use monitoring software like CPU-Z to check the operating frequency of your memory in the OS; if lower than expected, check your motherboard's overclocking profile is turned on.

If overclocking profiles don't work, manually set target frequencies and timings. You need to know the exact memory timings (including CAS latency) to do this, but they shouldn't be hard to find online with the product number.

Meddling about in the BIOS settings actually might solve your problem!

Finally, your components might be busted! We always recommend buying with a warranty, and if you receive a defunct part, you should be able to secure a replacement.

© MSI

10 RUSTY CAGE

BEFORE YOU CAN INSTALL the HDD, you'll need to fit one of the drive cages. You can situate this anywhere near the front of the case, but we're choosing the lowermost mounting spot to keep it out of the way of the rest of the system. Remove the plastic cover by pinching the clasp on the rear and popping it out of the cavity, then take one drive cage from the Enthoo Pro 2's accessory and insert the IronWolf Pro drive. It should be inserted connector-first, so you'll be able to connect it up behind the motherboard.

Using four of the short, thick screws from the accessory box, screw the HDD into the cage on both sides. This can be somewhat fiddly thanks to the rubber grommets around each screwhole, but the anti-vibration benefits are worth it. Next, position the drive cage against the mounting spot using the two hooks on the rear. You can then fix it in place using two of the thumbscrews from the Pro 2's little plastic case.

11 WE GOT THE POWER

THE LAST COMPONENT going into this case is the PSU. Figure out what cables you need first; for this build, you'll want one PCIe cable, two CPU cables, one Type 4 motherboard cable, and one accessory power cable. Plug all of these into the PSU before installing it—connecting them once it's in place will be more difficult.

Open the hinged plate behind the PSU shroud, and gently place the power supply on the foam pads. The PSU fan should be visible. Screw the power block to the back of the case using four of the provided screws. You've got to do some immediate cable routing here, starting with threading the PCIe cable through the hole in the side of the PSU shroud and plugging it into the GPU (you'll have a loose two-pin connector, but don't worry about it). Then, replace the hinged plate. There are two gaps to route cables out from under the plate: The accessory cable should be fed through the lower side gap, while the remaining power cables should be routed out through the top. Feed these through and connect them to the mobo. Connect the HDD and pump power connector to the accessory power cable.

12 CABLE FABLES

IT'S EVERYONE'S FAVORITE STEP: Cable management! We recommend using the extension cables and Y-cables included with the Noctua fans to plug those in to the SYSFAN1 and SYSFAN2 headers. Beyond that, though, there's nothing too complicated to deal with here. Find the closest hole to each port on the motherboard, and feed the appropriate cable through it. You may want to loosen the Velcro straps that hold the front I/O cables in place, but we'd avoid removing them entirely, as recontaining those cables can be a real pain.

Good cable management is important, but remember that this is a windowless case: Nobody's going to see any mess you leave behind, so don't stress out over making the cables look perfect. The Enthoo Pro 2 isn't the best case we've worked with when it comes to cable routing, but there's plenty of places to secure and bundle cables to keep things neat. Tidy cable work may prove invaluable later on, if you decide to upgrade (or clean) your system.

1 **The radiator is a bit difficult to screw into place, but performs excellently once mounted.**

2 **Storing the HDD down here keeps it away from cable clutter in the rest of the case.**

3 **The RGB memory can be used to display system temps via color-coded lighting.**

4 **The dust filter on the underside of the case slides out for easy cleaning, while others are held in place magnetically.**

MEMORY MADNESS

THIS WAS A SURPRISINGLY easy build. The Enthoo Pro 2 needs more cable-management solutions, but it's a big case with a bunch of useful tricks up its sleeve to make the build process run smoothly. Installing extra drives or case fans is a cinch; the upgrade potential for this build is nearly unlimited. There's a ton of space for extra HDDs and SSDs, and our power supply has more than enough juice for them. The M.2 Aero riser card packaged with the motherboard means we could have up to seven M.2 SSDs—excessive for us, but perhaps not to those who routinely handle vast quantities of data.

The Threadripper 3970X dominated our benchmarks, surprising nobody. Those 64 threads made short work of every CPU-bound task we threw at it, from Cinebench R15 to the more data-oriented HiBench (missing from our table, as we don't have a comparable zero-point). Graphical performance was also solid, as expected from the RX 5700 XT. You may want to swap out your GPU based on whether you need 3D-modelling and rendering performance.

The Sabrent Rocket 4.0 did well, only lagging behind the Corsair Force MP600 by a few percent. In practice, this won't be a noticeable difference; performance does tend to drop during lengthy file transfers as the drive heats up, but this is true of just about any M.2 SSD. The IronWolf Pro HDD didn't blow us away, but it spins quietly and provides plenty of initial storage.

Thermal performance was reasonable throughout our tests, although we'd advise upgrading to a beefier cooling solution if you've got manual overclocking in mind. Since this machine was tested in a living room during a heatwave (rather than our climate-controlled office space), our results and temps may have been skewed. There's a lot of variables, but our core temps never got too high during general testing.

We did have some serious memory issues. Despite the MSI Creator motherboard being rated for up to 256GB of memory and 3200MT/s via either JEDEC standard or A-XMP, we weren't able to get our 128GB kit running any higher than a measly 1866MT/s. This was incredibly annoying, until we were able to pull half the sticks and get the system running at the advertised 3200MT/s with 64GB, A-XMP enabled.

Keep an eye out for our Lab Note next issue: We'll reach out to MSI and try to get to the root of this issue. We had limited time to get this machine up and running, so we pushed ahead and ran our tests with half the memory, but we'll spend some time figuring out the problem and (hopefully) enlighten you in a month's time! If you're looking to build this system, we'd advise waiting for our results. Or, you could simply buy a cheaper 64GB memory kit and go from there.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Single (Index)	192	202 (5%)
Cinebench R15 Multi (Index)	2,952	7,341 (149%)
Fry Render (m:s)	01:17	01:06 (17%)
AIDA64 Memory Bandwidth (MB/s)	55,051	87,239 (58%)
AIDA64 Memory Latency (ns)	71.4	86.4 (-17%)
CrystalDisk QD32 Sequential Read (MB/s)	4,992	4,983 (0%)
CrystalDisk QD32 Sequential Write (MB/s)	4,284	4,253 (-1%)
CrystalDisk QD32 Random 4K Read (MB/s)	60	59 (-2%)
CrystalDisk QD32 Random 4K Write (MB/s)	220	213 (-3%)
Total War: Warhammer II (fps)	54	33 (-39%)
3DMark Fire Strike (Index)	21,453	16,786 (-22%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 9 3900X, 32GB (4x8GB) G.Skill Trident Z RGB Neo @ 3600, an EVGA GeForce RTX 2080 Super XC Ultra, and a 1TB Corsair Force MP600 M.2 PCIe 4.0 SSD. All game tests were performed at 3440x1440 on Ultra.

CLOCK WORKS

Want to be a competitive overclocker? Here's how to get started, by **Scharon Harding**

OVERCLOCKING boosts your performance, but what about your street cred? You can boast about your achievements to friends, but when you're ready to show the world your skills, there's competitive overclocking. Competitors enjoy a vast community online and at events worldwide. There are also prizes for winning competitions and breaking records. Competitive overclockers' ultimate destination is HWBot, which hosts global overclocking competitions and maintains a database of world records. Place near the top of one of its ranking boards, and you've made it.

Sound exciting? For those new to overclocking or interested in competing, we're here to help. Here are successful professional overclockers' best tips for getting started.

Start with CPUs or RAM, not graphics cards. Premium graphics cards are usually more expensive than CPUs or RAM kits, so you'll be more upset if you kill one by pushing it too hard. CPUs and RAM are also easier to overclock.

CPUs are the most popular starting point. Like other components, they also have built-in safety features, like thermal throttling, to help avoid damage from excessive voltage or inadequate cooling. In addition, keeping your CPU's heat at bay is easier than cooling "most reference GPUs" according to Albrecht Mesotten, who's been competing since 2009. "It's also much easier to test stability for a CPU than for a GPU," he added.

You don't need the most expensive components. When you check out the top scores on HWBot, you'll see premium, expensive components listed. This makes the idea of buying your way to the top enticing, but overclockers we spoke to said you don't need the priciest components—you can still gain points and move up the rankings with older parts. And competitive overclocking is about more than pushing GHz, so getting the most expensive components and binning them to find the highest possible clock speeds doesn't guarantee you victory.

Mesotten points to the different requirements needed for the benchmarks, such as operating systems, even outdated platforms like Windows XP. One of the trickiest parts is that you need a multitude of operating systems available for your setup to get the best performance. If you spend a lot, you'll be that much more in the hole if a product gets damaged.

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LN2 does look seriously cool in action. (Pun intended.)

BEYOND AIR COOLING

If you're air cooling your CPU, you'll probably hit a maximum of 4.8-5.2GHz on Intel's 7th generation and later K-series processors, depending on your luck with the silicon lottery—variances in silicon that result in different performance among processors with the same model number. AMD's 2nd-generation Ryzen processors will reach 3.8-4.2GHz with a beefy air cooler. If you want to go higher, you need to upgrade your cooling, a milestone for serious overclockers. To be highly competitive, you'll want to get into liquid nitrogen (aka LN_2).

But you don't have to start with LN_2. Cooling is one of the biggest challenges for newbie overclockers. So, consider working your way up from air or water cooling to single-stage cooling and cascade cooling, before graduating to liquid nitrogen. "Whether the new overclocker wants to do 2D processor benchmarking or 3D graphics card benchmarking, the most important aspect to overclocking is ambient cooling testing. The first step for beginners is to obtain a high-performance air cooler or some variety of liquid cooler," David Miller, a competitor since 2010, told us. Also, consider building your own water-cooling loop. Mesotten said that, while all-in-one water coolers are nice, they don't offer the same performance as a custom setup.

Single-stage cooling uses a compressor that can let you reach sub-zero temperatures—around -40C to -60C. When you move on to cascade cooling, you can hit around -80C. But liquid nitrogen will let you drop your CPU temps even further, to -197C.

TOOLS OF THE TRADE

Choose your equipment with care. Enthusiasts are very vocal about their preferred brands. Unfortunately, however, there's no magic formula of brands and products that'll guarantee a record-breaking rig, but we did get some advice from the experts for building your overclocking system.

"It's always good to test each individual component and then build them up. The trick is really to find each particular component that is good, and then bring them in and build something out of it. Because if you have one weak component, obviously that's going to be your weakest link," Joe Stepongzi, a competitive overclocker since 2009, explained. "It is good to test each individual component separately in some way, so we use different benchmarks to do that. Once we're happy with that, we bring them all together and put it to work."

This is what sub-zero overclocking demands at the professional level.

The LN_2 flask in the foreground here is an Intel-certified vacuum flask.

Liquid nitrogen is serious business, but get started with simpler cooling options.

CHOOSING COMPONENTS

Which CPU is best to start your overclocking career? Experts we spoke to recommended Intel's K series, such as the 8700K or 9900K, which are unlocked for overclocking. Mesotten advises against high-end, non-K Intel CPUs, since these are locked and not as overclockable. Almost all AMD CPUs have unlocked multipliers, which will help you bring out a few hundred MHz of extra power.

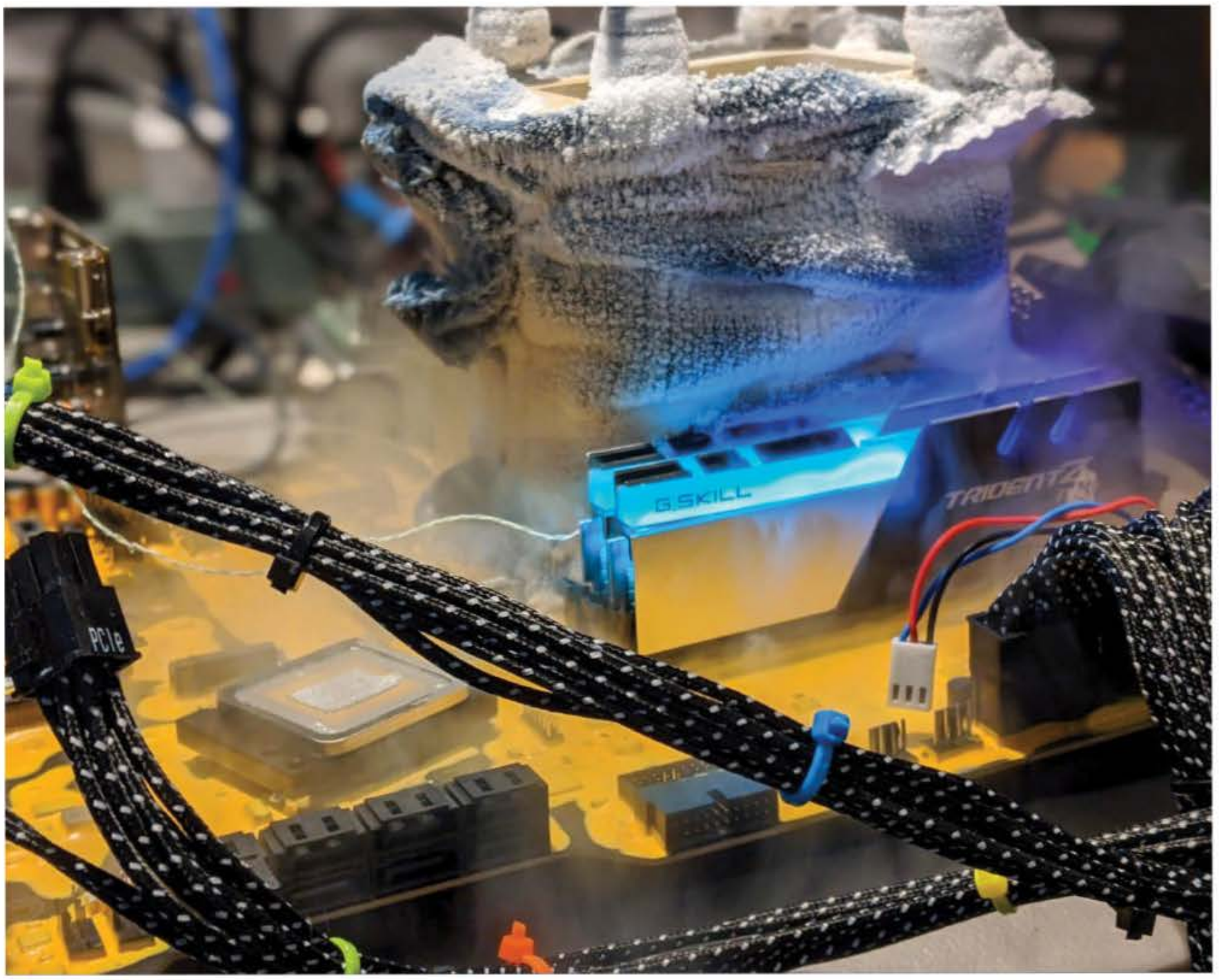
To work with a motherboard with the Z390 chipset, a popular platform for Intel overclocking, look for memory modules based on Samsung B-die integrated circuits (ICs). This type of memory has become synonymous with high-frequency, tight timings, and the most efficient benchmark results, and certain Intel Extreme Memory Profiles (XMPs) are nearly impossible to hit without Samsung B-die memory.

8GB RAM modules with Samsung B-die are popular and typically sold in kits of two. According to Miller, when buying RAM, the main factors to consider (besides memory size and physical features) are clock speed and timings. Depending on the operating frequency, Miller recommends looking for the following timings for a better chance of ensuring you get Samsung B-die silicon:

RAM Maximum Clock Speed	Timings
3200MHz	14-14-14
3600MHz	16-16-16
4133MHz	19-19-19,19-21-21

SELECTING A MOTHERBOARD

Motherboard choice depends on the competition you're entering—you can be tasked to work with older technologies, such as Slot A, the socket formerly used by AMD's desktop Athlon CPUs. Mesotten recommends a motherboard that gives



Accept that your competitive overclocking system isn't going to be pretty.

you ample BIOS settings, and both he and Stepongzi pointed to Asus, whose ROG line is built for gaming and overclocking.

Remember, it's not just about clock speed, so you'll want the flexibility to do things like tune memory and dial other settings. "Many overclockers prefer Asus because all the BIOS settings are there, and that's the most important thing. We don't have enough options with the standard BIOS settings," Mesotten said. For overclocking RAM, Miller suggests picking a motherboard with two DIMM slots for memory, which are "far superior" to four-DIMM motherboards, as there's a shorter distance between the CPU and DIMM slots.

POWER AND COOLING

A decent power supply is a priority for any overclocking rig; you don't want to be falling short on power delivery. As such, consider high-end brands, such as Cooler Master, Corsair, and Seasonic. Mesotten recommends a PSU with a minimum of 1,000W for overclocking a single component. But if you're overclocking multiple graphics cards or using an extreme cooling method (like LN_2), he recommends going up to 1,200W.

Additionally, Stepongzi believes your PSU choice should, to a certain degree, depend on the benchmark. Depending on the benchmark, an 18-core CPU can pull 1,300-1,400 watts. You'll need a solid power supply because many will trip the OCP (overcurrent protection) at a certain wattage and shut down. For example, overclocking an 18-core CPU with liquid nitrogen can even trip a circuit breaker in a U.S. home if you have other electronics connected to the same circuit. (Pro tip: Stepongzi usually finds a separate circuit in his house to run the PSU for overclocking, and connects any other electronics to a different circuit.)

Make sure that you have a good temperature meter and temperature probes. Stepongzi recommends the Fluke 52 II dual-probe digital thermometer. If you plan on working with liquid nitrogen, you'll need a dewar, which is a type of vacuum flask for storing cryogens. Stepongzi usually opts for 30-liter dewars. A dewar can cost hundreds or even thousands of dollars when new, but you can find them for a couple of hundred bucks on eBay. (Warning: you may sometimes come across listings that discuss storing cow semen, another use for dewars). Stepongzi noted that in the U.S. you can also rent dewars from welding supply companies, such as Airgas.

While you're at it, you should consider grabbing yourself a dewar flask for distributing liquid nitrogen, which usually occurs by pouring it from a large dewar into a flask, and then to the "pot" that holds the LN_2 and mates with the component. Also, consider buying a blow torch to heat the pot when needed. For any sub-zero cooling, Miller favors Kingpin

Ideally, you need some room for a dedicated overclocking workbench, like David Miller's.

products, including the T-Rex line of CPU containers ($325-$399) and KPx thermal paste ($11.99).

THE OTHER BITS

Miller recommends that you get at least three SSDs. You probably won't need more than 60GB per drive, but it's good to get a few for storing different operating systems. "When I use liquid nitrogen to overclock for world rankings, I often use three or more different operating systems in one afternoon. For this reason, it is not only convenient but also necessary, to pre—load SSDs with various operating systems in order to quickly change tasks," Miller explained.

If you do eventually go down the GPU route, Stepongzi said that "Nvidia GPUs are the fastest," (which we second) and points to the GeForce RTX 2080 Ti as the best option.

MORE THAN SPEEDS

The best overclockers aren't just focused on boosting clock speeds but are also interested in demonstrating the ability to drive better performance from a system—perhaps without adjusting any voltages. We're planning ahead here, but to further your ranking after breaking the top 10 in a particular category, you'll have to do tweaking that takes you beyond growing GHz. More advanced tactics (such as playing with driver settings, trying an older version of a driver, or another operating system) are what it takes to cross the threshold into true competitiveness and eventually improve your ranking.

For example, Superpi 32M is a single-threaded benchmark that's very sensitive to memory usage and speed. Mesotten said that benching it on Windows XP leads to better overclocks than on Windows 7. He also pointed to legacy 3DMarks, where you'll get better scores with Windows XP and Windows 7 than Windows 10. By using the newer systerms you can expect a drop in efficiency and, therefore, your competitive score. Today's competitive overclockers often need 32-bit and/or 64-bit versions of Windows XP, 7, 8.1 and 10, depending on the benchmark.

An example with drivers can be seen in older AMD GPUs, where overclocking with an older driver can make a "huge" difference, depending on the benchmark, according to Mesotten. He noted that you would likely see better performance on the GPUPi benchmark with an older SDK AMD driver.

A disappointing score may make you want to push voltage sliders to their maximum or trash your current setup and start from scratch. However, it's better to do one tweak at a time and then test those results, rather than make multiple changes at once. Mesotten points to a triangle of sorts—speed, temperature and voltages—that you have to push, yet also keep in a "safe zone" without straying too far. "A lot of times if you change too much when you're going through a system it ends up causing more issues, and you just bang your head everywhere," Stepongzi explained.

When you start competing, first develop some good testing practices and methods that you'll use all the time. You can listen to others' advice, but Stepongzi advised that you need to work on this yourself a bit to "find yourself and your own setup." And know when to stop. If your motherboard shuts down erratically or you're getting blue screens, it's time to pause to avoid breakage. These things are usually a sign that condensation is forming somewhere, according to Mesotten. For GPUs, Mesotten recommends increasing clock speeds 25MHz at a time. Test your favorite game, and if things are stable, you can push some more.

© DAVID MILLER / HWBOT

Screenshots posted alongside test results can provide clues to improve your overclocking.

AIO coolers are a good starting point for rookie overclockers.

A 1000W+ PSU is a must for hardcore frequencies and voltages.

When benchmarking, Miller said that it's best to focus on one test at a time and learn to perfect your score by running it repeatedly before going for more aggressive overclocks. The goal is to keep the processor, memory, and motherboard settings constant while you compare the scores on different operating systems and different settings within the operating system. There are many factors besides processor speed that can affect the score in Cinebench R15, for example.

"Simply comparing... Windows 10 and Windows 7, for instance, one will find that the score on Windows 7 is substantially better. One might even see a score variance of up to one percent between each benchmark result without changing anything. Committing your time and energy to one benchmark and learning everything you can about it is the best way to succeed," Miller said.

WE LIVE IN A SOCIETY

Overclocking communities can really help you boost your competitive edge and achieve better efficiency and scores. You can use them to find other overclockers willing to critique and advise on your set-up, testing, and scores. Check out forums like *Tom's Hardware*. www.overclock.net is also friendly for noobs and has a large and successful USA overclocking team.

There are also communities to tap on HWbot and even Facebook. Look for people you can relate to who aren't against sharing information. You can also check out YouTube, including channels like Stepongzi's Bearded Hardware. Finally, get free tips from scores posted on HWBot. Look at the screenshot for things you may not have considered, such as driver versions, operating systems, or tweaking tools used.

Start off with team competitions. When you're ready to compete for the first time, it's better to enter as a team instead of solo. You get the backing and knowledge of an entire team to help improve your best overclocks. Additionally, you'll get access to honest feedback on whether you have a potentially winning score or not. You may think you have an idea of how you'll rank by looking at scores already posted, but overclockers often sandbag and withhold their best scores until the competition's about to close.

PICKING A TEAM

You can join a team on HWBot, but our experts recommend starting off on an Overclock.net team for your first time because of the site's novice-friendly nature. Stepongzi also recently launched a team on HWBot (called Bearded Hardware) specifically for people looking to learn. When submitting scores, be thorough and share pictures. You can find HWBot's general rules and guidelines on the website. Each individual competition has its own regulations and requirements, so be sure to read those thoroughly too. If you fail to meet a requirement and there's not enough time to remedy it, you may end up being disqualified.

But it's not just about being eligible. HWbot is a database, so your results will be stored for a while. Producing detailed, informative submissions is a good way to make a name for yourself, especially if you're new to the world of competitive overclocking. So be sure to share screenshots and, if possible, pictures of your system and components. "Try to take pictures; don't just put up a score. Most people want to see how you did it and what you're about," Stepongzi suggested.

SPONSOR UP

Getting sponsored helps but comes with challenges. Many of the best overclockers, including Miller and Stepongzi, are sponsored, which means that a component company supplies them with products, making it cheaper for them to compete. But those free components come with a lot of pressure attached. Those vendors expect you not just to win competitions, but to break world records. Meeting expectations is not easy. For example, a CPU that a company expects to run at 5.8 Hz may end up running slower thanks to the silicon lottery. Some sponsored overclockers find themselves forced to test almost nightly, because if a product from another vendor is posted with a higher score, they get a call from their sponsor, who always wants to hold that number-one spot.

Still, Stepongzi, who found his first sponsor a year after competing, feels that to be really competitive, you need a sponsor. Sponsors reach out to overclockers, or you can reach out to them. But in either scenario, you'll need proof that you have what it takes to overclock their product to the top of the record books. Being in the top 20 or top 10 in the world is a good way to get attention.

"You just need to get your name out for name recognition. it kind of works from there. The trick is to almost take anything off the bat, and work for it and show people what you can do. Because if you want to get into this world, you need to show them first," Stepongzi said. "An opportunity can come out of nowhere: You'd be surprised."

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ARMing the

Apple is dumping Intel processors for its own ARM-based designs. Will the traditional PC be next?

Fugaku: We don't even know what you'd do with 415 petaflops, but apparently it runs Linux.

World

NO ONE WOULD HAVE BELIEVED in the last years of the 20th century that the processor world was being watched keenly and closely by intelligences greater than Intel's. Yet across the gulf of the Atlantic in a country called the UK, intellects vast and cool regarded the processor market with envious eyes, slowly and surely drawing their plans against Intel...

Apple is dumping Intel processors for its own design of silicon. How did this happen, and what, if any, are the ramifications to the wider PC market? How can a processor design that started life in an obscure, failed British home computer of the 1980s now challenge the entire Intel empire? We're going to delve into the ARM microarchitecture, have a look at how it's advanced over the years, how those architectural advances have borne out in benchmarks, and contrast the results to those of Intel desktop parts.

As we do this we're going to find two contrasting stories: One of maximizing performance increases generation by generation, and the other offering fixed incremental increases from generation to generation. We can delve behind the reasoning for why those increases played out like they did, and we can argue if ultimately those have been good decisions or not.

We can also argue about competition in the marketplace and ultimately how that's good for us, the consumer. But an architecture running an entirely different instruction set—is that good for PC consumers? Perhaps we're getting ahead of ourselves. **–NEIL MOHR**

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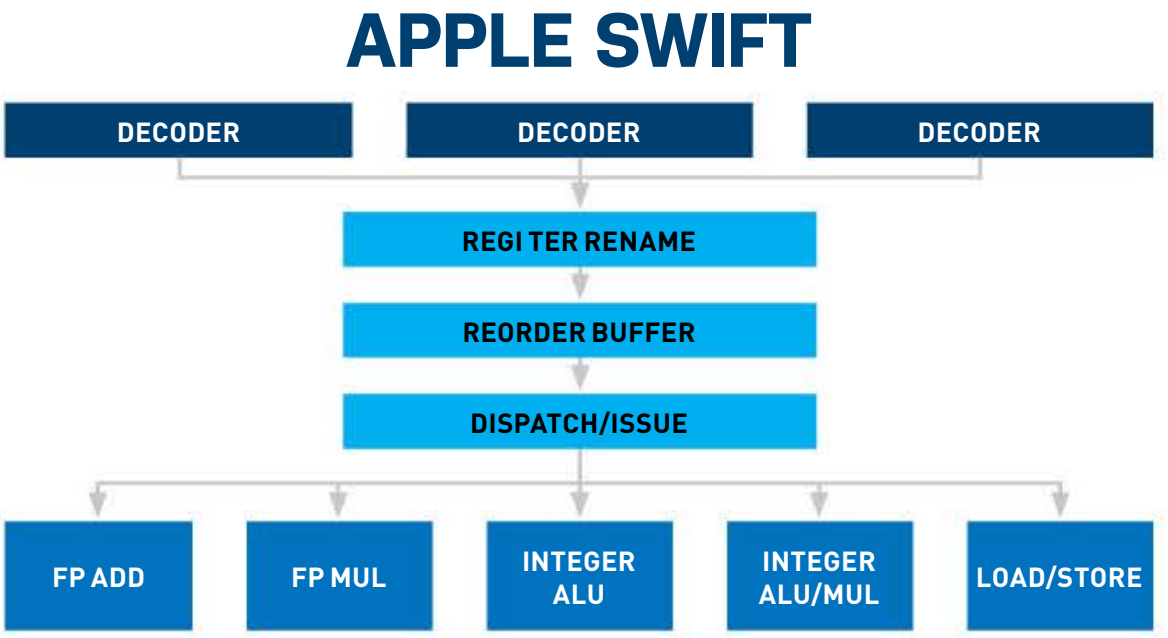
WHAT IS AN INTEL PROCESSOR? What is a PC? If you hark back to *Maximum PC*'s December issue in 2019, John Knight wrote about the history of the PC as a standard. When IBM was part-picking, it could have gone with its own IBM 801 RISC processor, but the budget insisted on the Intel 8088, and history was set: Every compatible PC would be running an x86-compatible processor.

Technically anyone "could" design and manufacture an x86-compatible processor, but legally Intel owns the patents to the instruction set and has to license it for that to happen. If a company has ever produced a design or manufactured an x86 processor, it's because Intel (or a court) allowed it to. AMD is different, as it has a complete cross-patent licensing agreement with Intel, so the two companies don't end up suing each other into oblivion.

Over the years there has been a choice of different x86 manufacturers: IBM made a range of 386/486 processors, AMD, Cytrix, VIA, NEC, Transmeta, and some others, with the running theme usually being low-end designs. Intel has always been the x86 top dog, with the others (apart from AMD and the IBM days) being also-rans. So you could argue there has been competition in the market, if fighting over the dregs counts as competition.



The 2012 Apple-designed Swift core was a huge step forward.

The point is that there's almost no competition for Intel in the market—even today with AMD doing well it commands just 18 percent (Mercury data) of the consumer market. AMD itself said it was aiming for 10 percent of the server market in 2020 and aiming to claw back to the heights of the Opteron days during 2006 of a heady 25 percent market share.

It's fine to lament the lack of competition, but what can possibly change to break the status quo? The big recent announcement is that Apple will start to move away from Intel-based processors and switch all of its hardware to its own design of processor. Apple's not talking about just laptops or low-end iMacs, but even its high-end workstation offerings that use the Intel Xeon. It's a bold statement, but how is it going to manage?

SIMPLER TIMES

As we've alluded to, it ain't going to be an x86-based processor. As you know, Apple makes the iPhone, which it turns out is rather popular. They also tend to be the fastest phones on the market, by quite some way. It could use whoever designs those mobile processors to come up with something for its desktop systems! Who designed those processors again? Apple, using the ARM-licensed Instruction Set Architecture (ISA).

For those that don't know, ARM is a Reduced Instruction Set Computer (RISC), whereas x86 that is a Complex Instruction Set Computer (CISC). We have previously looked at RISC in *Maximum PC*'s December 2018 issue, so if you're interested in the history of where RISC came from then grab a back issue!

Just to touch upon the background, the design philosophy behind RISC is to optimize the instruction set, to ensure instructions can be run in a single memory cycle and to eliminate unnecessary instructions to an optimized core. As time has progressed, instruction sets have grown, especially with specialized cryptography/vector/SIMD functions. So the "reduced" part is now misleading.

There are interesting consequences from those design decisions. Optimizing the instruction set reduces the number of transistors being used, and that reduces the amount of power required to do anything. So x86 and its CISC design

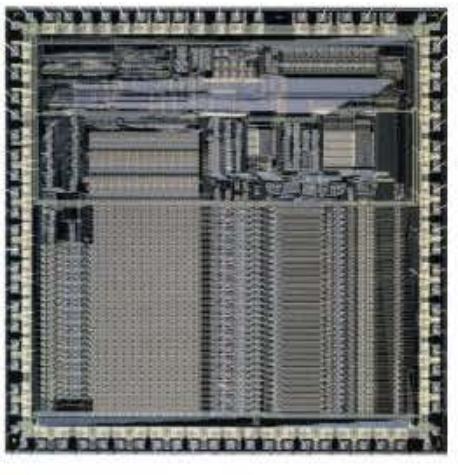
THEY SEEM ARMLESS

Back in the 1980s CISC seemed fine, but a plucky UK company called Acorn Computers Ltd wanted a processor to take on the IBM PC, Amiga, Atari ST, and Apples of the world. Its hard work in 1985 produced the ARM1, and to try and put its achievement into scale, Acorn Computers produced a fully functioning 32-bit CPU with just 25,000 transistors running at 8MHz. The original Intel 8086 has 29,000 and was an eight-bit CISC processor—contrast that to the Intel 286, which itself had 134,000 transistors and ran with a similar performance to the ARM2.

Even so, ARM could have disappeared along with Acorn Computers. However, a small US manufacturer called Apple decided it needed a low-power processor for a new PDA called the Apple Newton, and ARM Holdings was created in 1990 with investment from VLSI Technologies. The ARM architecture needed additional work, such as an integrated memory management unit and full 32-bit address-space support.

This culminated in the release of the ARM6 running the ARMv3 architecture in 1992, which is effectively what's largely used today, only with an increased transistor count up to 36,000. That's for the basic core—tacking on the MMU and 4KB cache increases this count to around 360,000. The ARM610 was at the heart of the Apple Newton released in 1993 and also licensed by DEC to make the StrongARM. While the Apple Newton might have died off, its investment in ARM didn't.

By 1998 Arm partners were shipping 50 million ARM-powered devices. In 2001 ARM had 76-percent of the 32-bit embedded RISC market and had 25 companies licensing its technology. By 2002 ARM partners had shipped more than 1 billion cores. By the end of 2019 ARM had shipped over 160 billion cores in total and 6.4 billion in the 4th quarter of 2019.



Get counting—there's 25,000 transistors, and we're not going home until they're all accounted for.

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ARM MOBILE PROCESSORS

Year	Model	CPU	Frequency	Architecture	Cores (little)	Total CPU Cache	Geek bench 2 (32-bit)	Geek bench 3	Geek bench 4	Geek bench 5	Geek bench 2 (32-bit)	Geek bench 3	Geek bench 4	Geek bench 5
							Single Core Results				% Increase (Gen on Gen)			
2007	iPhone 1	Samsung	412 MHz	ARM11	1	32 KB	135							
2009	iPhone 3GS	Samsung	600 MHz	Cortex A8	1	320 KB	280	150			107%			
2010	iPhone 4	Apple A4	800 MHz	Cortex A8 Hummingbird	1	576 KB	378	206			35%	37%		
2011	iPhone 4S	Apple A5	800 MHz	Cortex A9	2	1,064 KB	617	215			63%	4%		
2012	iPhone 5	Apple A6	1.3 GHz	ARMv7-A Swift	2	1,064 KB	617	712	754		156%	231%		
2013	iPhone 5S	Apple A7	1.3 GHz	ARMv8-A Cyclone	2	5,128 KB	2,224	1,401	1,266	259	41%	97%	68%	
2014	iPhone 6	Apple A8	1.4 GHz	ARMv8-A Typhoon	2	5,128 KB	2,421	1,599	1,459	308	9%	14%	15%	19%
2015	iPhone 6S	Apple A9	1.8 GHz	ARMv8-A Twister	2	11,128 KB	2,985	2,506	2,382	541	23%	57%	63%	76%
2016	iPhone 7	Apple A10	2.3 GHz (1.05 GHz)	ARMv8.1-A Hurricane	2x2 (Zephyr)	7,128 KB	2,985	3,427	3,444	741	20%	37%	45%	37%
2017	iPhone 8	Apple A11	2.4 GHz (1.xx GHz)	ARMv8.2-A Monsoon	2x4 (Mistral)	8,064 KB		4,269	4,212	919		25%	22%	24%
2018	iPhone XS	Apple A12	2.49 GHz (1.5 GHz)	ARMv8.3-A Vortex	2x4 (Tempest)	8,256 KB		4,773	4,795	1,106		12%	14%	20%
2019	iPhone 11	Apple A13	2.66 GHz (1.82 GHz)	ARMv8.4-A Lightning	2x4 (Thunder)	28,000 KB			5,471	1,325			14%	20%

INTEL DESKTOP PROCESSORS

Year	Model	CPU	Frequency	Architecture	Cores (little)	Total CPU Cache	Geekbench 4	Geekbench 5	Geekbench 4	Geekbench 5
							Single Core Results		% Increase (Gen on Gen)	
2009	Core i7	860	2.8 GHz	Nehalem	4 (8)	9,024 KB	2,188	508		
2010	Core i7	970	3.2 GHz	Westmere	6 (12)	13,536 KB	2,652	594	21%	17%
2011	Core i7	2600K	3.4 GHz	Sandy Bridge	4 (8)	9,024 KB	3,014	811	14%	37%
2012	Core i7	3770K	3.5 GHz	Ivy Bridge	4 (8)	9,024 KB	3,904	866	30%	7%
2013	Core i7	4770	3.4 GHz	Haswell-DT	4 (8)	9,024 KB	4,261	910	9%	5%
2014	Core i7	5820K	3.3 GHz	Haswell-E	6 (12)	16,536 KB	4,533	917	6%	1%
2015	Core i7	6700	3.4 GHz	Skylake-S	4 (8)	9,024 KB	4,661	979	3%	7%
2016	Core i7	6800K	3.4 GHz	Broadwell-E	6 (12)	16,536 KB	4,714	918	1%	-6%
2017	Core i7	7700	3.6 GHz	Kaby Lake-S	4 (8)	9,024 KB	5,193	1,061	10%	16%
2018	Core i7	8086K	4.0 GHz	Coffee Lake-S	6 (12)	13,536 KB	6,423	1,335	24%	26%
2019	Core i7	9700KF	3.6 GHz	Coffee Lake-S	8 (8)	14,048 KB	6,760	1,340	5%	0%

Year	Model	CPU	Frequency	Architecture	Cores (little)	Total CPU Cache	Geekbench 4	Geekbench 5	Geekbench 4	Geekbench 5
							Single Core Results		% Increase (Gen on Gen)	
2009	Core i5	750	2.67 GHz	Nehalem	4	9,024 KB	2,297	500		
2010	Core i5	650	3.2 GHz	Westmere	2	4,512 KB	2,305	519	0%	4%
2011	Core i5	2300	2.8 GHz	Sandy Bridge	4	7,024 KB	2,859	599	24%	15%
2012	Core i5	3330	3.0 GHz	Ivy Bridge	4	7,024 KB	3,110	656	9%	10%
2013	Core i5	4430	3.0 GHz	Haswell-DT	4	7,024 KB	3,646	757	17%	15%
2014	Core i5	4460	3.2 GHz	Haswell-DT	4	7,024 KB	3,720	797	2%	5%
2015	Core i5	6400	2.7 GHz	Skylake-S	4	7,024 KB	3,963	834	7%	5%
2017	Core i5	7400	3.0 GHz	Kaby Lake-S	4	7,024 KB	4,476	884	13%	6%
2018	Core i5	8500	3.0 GHz	Coffee Lake-S	6	10,536 KB	5,243	1,074	17%	21%
2019	Core i5	9500	3.0 GHz	Coffee Lake-S	6	10,536 KB	5,524	1,143	5%	6%

Geekbench Scores: https://everyi.com/ibenchmarks/index-ipod-iphone-ipad-benchmarks.html. SoC Specifications: https://blakespot.com/ios_device_specifications_grid.html

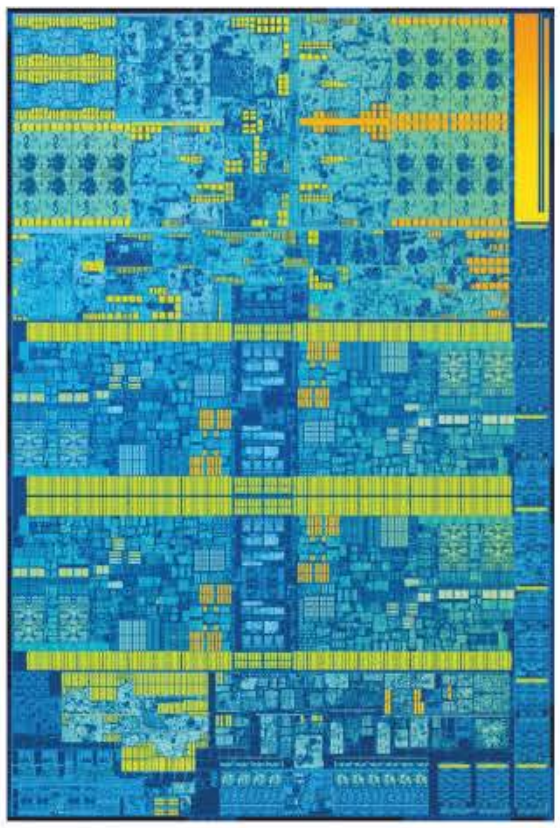
inherently requires more transistors to do any computational job and so more power. On desktop this isn't much of an issue, but with laptops and phones every watt counts.

This is why Intel's half-bothered (sure, you can argue) stab at the phone market failed, which, considering it does networking, you'd have thought would be a no-brainer. Its x86 Atom offerings were too power-hungry and didn't offer enough speed to differentiate the phones that used it. If Intel had backed it with more up-to-date process technology the story could have been different, but understandably it wanted to protect its core business.

JOIN THE ARMY

We're going to look at how both the ARM architecture and Intel desktop processors have improved over time (see page 41). It's notoriously hard to correctly compare two different architectures, so we're not, we're just going to look at Geekbench results as best we can. For ARM, we're going to look at scores through the lens of Apple cores (used in just the major iPhone releases) as they're the most performant, while for Intel we'll focus on base Core i5 and Core i7 models in corresponding release years. We'll keep an eye on the percentage speed increases. Alongside this we'll delve into the major changes in the architecture—mainly on the ARM side, but it never hurts to go back over the Intel updates.

ARM is an IP company that designs the specification for the ARM ISA and



The 2015 Sky Lake architecture has been pottering along since 2015.

updates it with new technology, such as its big.LITTLE core design, NEON SIMD instructions, and enhanced floating point units, for example. Typically it gives each new family release—the overall package of features—a name, such as Cortex-Ax; for Apple this started with the 32-bit ARMv7 within ARM11, and moves to designing its own microarchitectures using the various updates to the 64-bit ARMv8.

HIGH-PERFORMANCE COMPUTING

We hardly have to feel bad for ARM, it's not like it already owns the entire mobile phone and tablet space. In fact if things weren't already looking a bit grim for Intel on the desktop and laptop front, consider that its cash cow of the server market is now under attack not by just a revitalized AMD but ARM as well. Server farms for decades have grappled with the issue that cooling costs more than running the darn servers, two-to-one back in the day, and even now one-to-one costs are a mark of a good cooling design. So if someone appears offering a way of reducing the power consumption of your servers you're going to pay attention. That's exactly what ARM has been busy doing.

You might have heard of Amazon and its Amazon Web Services that runs half the web. With so much bare metal to pay for, anything that saves on energy will benefit Amazon. So it designed its own server processor core called Graviton, and in 2020 released Graviton 2. It's a 64-core SoC with 42MB of cache, running at 2.5GHz with eight-channel DDR4-3200 memory and 64 PCIe v4 lanes on the 7nm TSMC process. Estimates put power use at 100W vs 210W for a similarly pegged Xeon processor.

If that wasn't enough, the all-new Japanese Fugaku system has taken the top spot for supercomputing power, besting the PowerPC/Tesla-powered Summit system by 2.8x with a whopping 415.5 petaflops—but can it play *Crysis* using Fujitsu's 48-core A64FX Arm-based SoC. The UK's national meteorological office is also planning to go ARM with another supercomputer that should claim the number-three spot once up and running in August 2022, offering 145 petaflops—enough to predict the weather before it happens!

In the original iPhone, Apple used a Samsung-designed SoC that was based on ARM11, which was actually introduced in 2003 using the ARMv6 microarchitecture. This was designed with early phone use in mind and introduced the first SIMD (Single Instruction Multiple Data) instructions for MPEG playback, improved cache (just 32K), and an eight-stage pipeline. With limited out-of-order execution and branch prediction, the performance can't be taken as anything but weak.

The iPhone 3GS was the first really usable iPhone (in terms of software features). It stuck with a Samsung-designed SoC, but this used the updated Cortex-A8 core. Benchmarking shows a 107 percent increase in speed—put this down to the introduction of a dual-issue, superscalar 13-stage pipeline, backed with a 10-stage NEON SIMD pipeline for media acceleration. It doubled the L1 cache and introduced 256K L2 cache, and included a floating point unit. It's this sort of "low-hanging fruit" that ARM and Apple was able to easily leverage at these early stages to drive doublings in speed.

The Apple A4 was the first in-house designed SoC, and while it debuted in the original iPad at 1GHz it was also used later in the iPhone 4, but at 800MHz. If Apple did Intel's Tick-Tock design, this would be a Tock release. Still based on the Cortex-A8 architecture and the same Samsung 45nm process, it largely offered speed improvements via a clock increase and larger 512K L2 cache, but a key change was doubling the memory bus to 64-bit.

When Apple launched its iPad 2 it again introduced its all-new SoC—the Apple A5 at 1GHz—here first, and into the iPhone 4S later at 800MHz. The Apple A5 was a significant release for Apple; it switched to the updated Cortex-A9 design, and it was the first dual-core release. Using the same Samsung 45nm process, the clock wasn't increased, but the memory speed doubled to 400MHz, and the L2 cache doubled again to 1MB. The Cortex-A9 also introduced more fundamental key improvements, such as an eight-stage out-of-order speculative pipeline, enhanced NEON SIMD and double-speed FPU.

The release of the Apple A6 was when things started to get interesting from the point of view of Apple taking charge of its own design future and using its own ARMv7 design tricks. The Apple A6 was the last 32-bit design from Apple, and while it used the same size L1 and L2 cache as the A5, a process drop to 32nm, clock boost to 1.3GHz, and clever architectural introductions offered one of the biggest gen-on-gen increases, all the while using less power. The A6 appears to be based on

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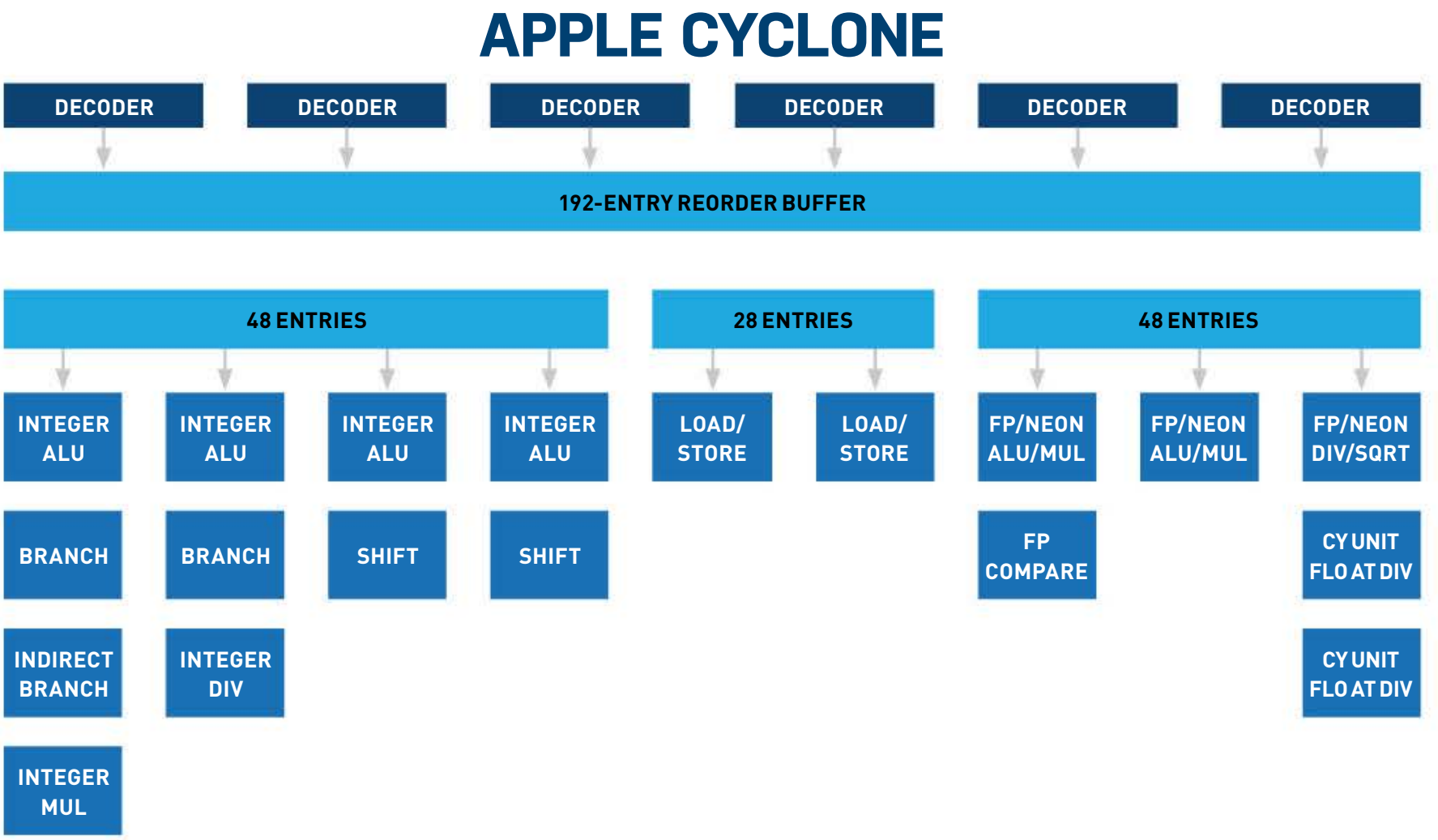


Moving to 64-bit ISA and a super-wide design for Cyclone.

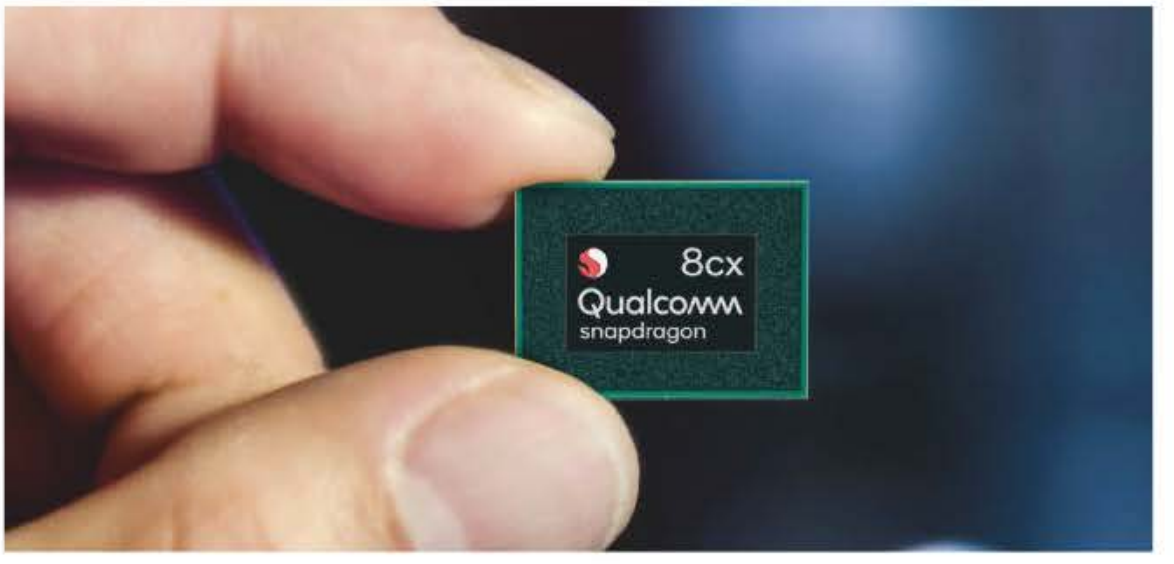
the Cortex-A9 but used advanced parts of the Cortex-A15 design, including two of its (then) new v4 FPUs and Advanced SIMD v2. Analysis indicates it could issue three commands and use five execution units (2 ALU, 2 FPU/NEON, 1 load/store) with a 12-deep pipeline. This massively enhanced the A6's FPU prowess, and with optimized cache and a dedicated load/store unit, memory performance increased threefold, and overall speed doubled, again.

At this point Apple hit its stride, and the Apple A7 release was another mobile first: A 64-bit processor almost a year before anyone else. Using the ARMv8-A architecture on a Samsung 28nm process Apple added a 4MB L3 cache, doubled L2 to 1MB and L1 to 128KB. Apple basically doubled the width of its processor with this release: six-issue wide, four ALUs, two load/store units, two branch units, and three FPUs/NEONs units. With a billion transistors, that's up 33 percent on the A6. For benchmarking we see the 32-bit only Geekbench 2 start to get long in the tooth, but Geekbench 3 points to the A7 Cyclone cores being twice as fast, again!

The Apple A8 remains a head-scratcher in terms of speed; it feels like Apple concentrated more on the GPU side—introducing an in-house custom GPU shader—and perhaps the shift from Samsung (now an arch rival) to TSMC on a new 20nm process was another distraction. Even with the transistor count doubled to 2 billion, the main architecture remained largely unchanged, with its six-issue, six-decode, nine-wide out-of-order design. The 20nm process enabled a modest bump in clock that would largely account for the improved results, and even Apple "only" claimed a 25 percent increase over the Apple A7.

It's a similar situation for the Apple A9 release, but utilizing the TSMC 18nm and Samsung 14nm processes Apple could bump the clock to 1.8GHz, and tripled the L2 to 3MB. Add to this doubling the memory bus speed, and you can account for the 70 percent increase in speed without much change to the architecture.

The two big shifts for the Apple A10 were the introduction of the ARM big.LITTLE technology that enabled high-power and low-power cores to balance power consumption, plus a drop to the TSMC 16nm production. The easy win here was a jump to 2.3GHz speed, made easier with the introduction of the two low-power Zephyr cores, which ran at 1GHz and used just 20 percent the power of the "big" cores. Apple also moved to the newer ARMv8.1-A microarchitecture, though this was an incremental update. This was the last Apple SoC to get a Geekbench 2 result, and we'd think all the increase is down to the clock increase, while newer Geekbench releases also



Expect to see more Windows-runninng ARM systems using Qualcomm SoC.

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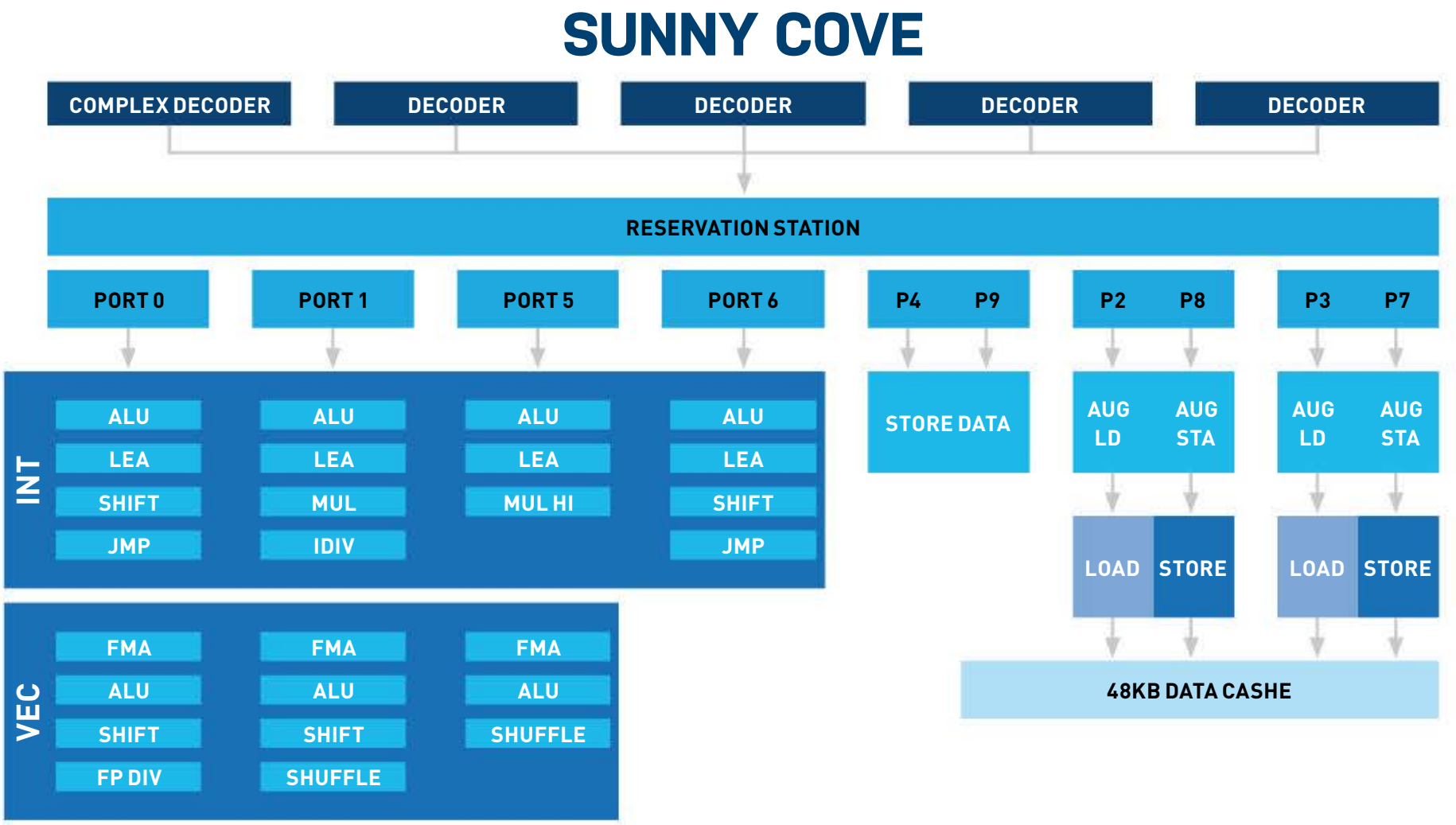

The current Sunny Cove is the first major Intel architecture update since Sky Lake.

include GPU elements that continued to increase significantly in speed.

The Apple A11 introduced a 2x big and 4x little core, it seems the small Mistral cores in the A11 were actually based on the Apple A6 Swift cores. Unlike in the A10, these could now work independently of the big cores—previously it was either or could be used. The big Monsoon cores were a major update in terms of the mid-core, moving from the six-wide decode to seven-wide. While in the backend was the addition of two integer ALU units, upping them from four to six units.

The Apple A12 was another advance for Apple, being the first commercial 7nm silicon. A big change was made to how the processor cache was organized, helping reduce latency and increase bandwidth. The general L3 cache was dropped in favor of an 8MB L2 system cache, and the L1 was doubled to 256K. The configuration was a little more complicated, split differently between the big.LITTLE cores—the A12 had two large and four small cores, and the small Tempest cores were Apple A6-based Swift cores.

The big Vortex cores actually had a single-thread turbo to 2.5GHz. The A11 and A12 were very wide architectures, even for desktop-class processors. With two complex units, two load/stores, two branch units, three FP/Vector units, that's potentially 13 execution units.

The current, latest Apple A13 sees Apple doubling down on its new cache system, now called System Level Cache, which gets a whopping 16MB to service the SoC. The little (Thunder) cores get 4MB L2 and the big (Lightening) cores get 8MB L2. The overall design of the A13 appears to be a similar seven-wide decode front end with improvements to the multiplier and integer units. The seven percent boost to clock speed doesn't account for the 14 to 20 percent speed increase Geekbench returns, even taking into account the 20 percent increase in the GPU.

ARMED AND DANGEROUS

There's no doubt that Apple is going to compete with Intel on the desktop; its processor design is as wide as a desktop design, and its System Level Cache is as large and efficient, but it's important to remember that this is unique in terms of ARM licensees. Apple is able to design such expensive silicon as it knows it's going to sell them in premium-priced products. It'll deliver better battery life and own another chunk of its device's costs, knowing it'll recoup its investment.

For 3rd-party processor manufacturers that model just isn't possible. Take AMD: It's never been able to compete with Intel and struggles even now when it's doing well. So is an ARM-based processor manufacturer going to swan in and take over the desktop (or even laptop) market from Intel and AMD? No—even ignoring software compatibility, which is much less of an issue today, on desktop where power consumption isn't an issue and price is competitive, it'd be hard for anyone ARM-based to get a foothold.

Where ARM systems are targeting x86 is on mobile. Take the latest Lenovo Flex 5G that runs a Snapdragon 8cx SoC. We don't have specifics on the SoC itself, but it uses the Cortex-A76 microarchitecture that is a four-way frontend decode, nine-port issue that has three ALUs, two FPU/SIMD units, two Load/Store units, and a Branch unit. While certainly capable, it's a fraction of what Apple is putting into its current-gen silicon, and that plays out in the Snapdragon Geekbench 5 single-core result of 716, less than half of the Apple A13. The Snapdragon is a quad-core part but ends up slower than the Apple A13.

With Intel stumbling over its process technology once again, Apple is at least matching its best core designs for performance, while ARM's licensed cores are set to challenge Intel Core i5-level mobile cores. With AMD squeezing workstation and performance parts, ARM is being deployed in the lucrative HPC (high-performance computing) and server arena. There's zero argument about it—Intel is getting squeezed from every direction.

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TIP OF THE MONTH

GET A SPUDGER!

Do you like Ryzen processors, but hate those delicate, exposed pins on the motherboard? Then you may want to invest in a spudger. This is essentially a tiny spatula (we recommend plastic ones, not metal) that can be used to carefully straighten up those pesky bent pins. We've salvaged more than one AMD chip with this nifty tool. And the best part? They're super cheap!

CHRISTIAN GUYTON
STAFF WRITER

INTEGRATE, ASSIMILATE

If you were reading *Maximum PC* last year when Intel's Iris Plus Graphics hit laptop processors, you'll know that I love integrated graphics. If you know me in person, I've probably talked your ear off, waxing lyrical about iGPUs.

And I'll do it again! I regret nothing, I haven't changed, and integrated graphics are still awesome. The latest to impress me was the Ryzen 7 4700G, a high-end Renoir APU packing eight cores and a hefty boost clock of 4.4GHz. Dedicated hardware heads have already managed to push that up to a 4.765GHz manual overclock, which is impressive.

But I'm here to talk about the new IGs. It's Vega, but not as we know it. The 4700G's graphics are very well-optimized, to the point where early testers have been throwing out impressive game demos using the chip sans GPU. I've seen *Doom Eternal*, *GTA V*, and *CS:GO* getting dominated by these powerful integrated graphics, but by far the most interesting was a *Death Stranding* gameplay test. It ran at a stable 30+fps at 1080p, graphical settings set to high.

The silicon lottery may play a role here, and we don't know the price of the 4700G yet, but it's not to be sniffed at. Integrated graphics are more viable than ever, and I'm excited to see Intel strike back.

MAKE – USE – CREATE

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The Kishi easily expands to accommodate your phone.

BACKGROUND

Razer's new Kishi Universal Controller is here to turn your smartphone into a play-anywhere system, with real buttons and joysticks. Join us as we tear down this stretchy controller to take a closer look at its inner workings.

MAJOR TECH SPECS

- Standard A-B-X-Y buttons, two clickable analog thumbsticks, one eight-way D-pad, plus a shoulder button and trigger button on each side
- Connectivity to a phone via USB-C or Lightning connector
- No internal battery, no Bluetooth, and no headphone jack
- Compatible with Android 8 Oreo/iOS 9 or higher, supporting device dimensions of 145.3-163.7mm (H), 68.2-78.1mm (W), and 7.0-8.8mm (D)

KEY FINDINGS

- Two slide locks on the back of the Kishi secure both halves of the controller, keeping it compact when there's no phone attached. Pulling outward on both inserts releases the clip, so you can extend the Kishi until your phone fits in between.
- We blast off 10 tri-point screws from the rear side. Thankfully we came equipped with 64 bits of Mako Driver Kit goodness. Beneath the back cover, we find two Steam-ish booby-trap interconnect cables—each one snaking off to a separate circuit board.
- Instead of the tri-points in other portable gaming options, we find Phillips #0 screws inside the handles. We're happy to go on a Phillips fetch quest. There's no boss battle here yet—just a couple of boards, which we quickly extract.
- On the back of the board is an ARM 32-bit Cortex-M0 CPU and breakout board for the second shoulder trigger, which is attached separately so is easier to repair. This one seems to use some sort of rotary knob, offering not only an on/off status but a gradual push depth of the shoulder trigger.
- Extracting the left circuit board reveals another joystick that is also soldered in place, four golden contacts for the D-pad (similar to the ones on the first circuit board), a soldered-on shoulder button, and a shoulder trigger breakout board. Gamevice has unmistakably left its mark here—in case you wondered with whom Razer partnered up for this controller.
- What remains is the telescoping slider mechanism that supports the phone. It includes a folding rubber cushion that attaches to the back cover with small springs, which saves you from worrying about scratches on the back of your phone while gaming. All external faces of the controller can be separated from the electrical components, which will make individual paint jobs a breeze.
- Quest complete! Let's recap: Easy disassembly (with the right drivers); some danger of losing small components and buttons; no ability to save your progress, so finish your homework and take out the trash before you start.
- Repairability Score: 6 out of 10 (10 is easiest to repair). No adhesive was used, and components are attached with screws. The controller's relatively modular construction means that replacing most components will be simple. One of the most strained parts—the phone connector—is plug-in and easy to replace. Using two different types of screw—one of them being tri-point—is unnecessary and a bit annoying. The components most likely to fail (both joysticks) are soldered directly onto the circuit boards, as is the passthrough USB-C charging port.

How to Delid Your Processor, and Why

YOU'LL NEED THIS

PROCESSOR

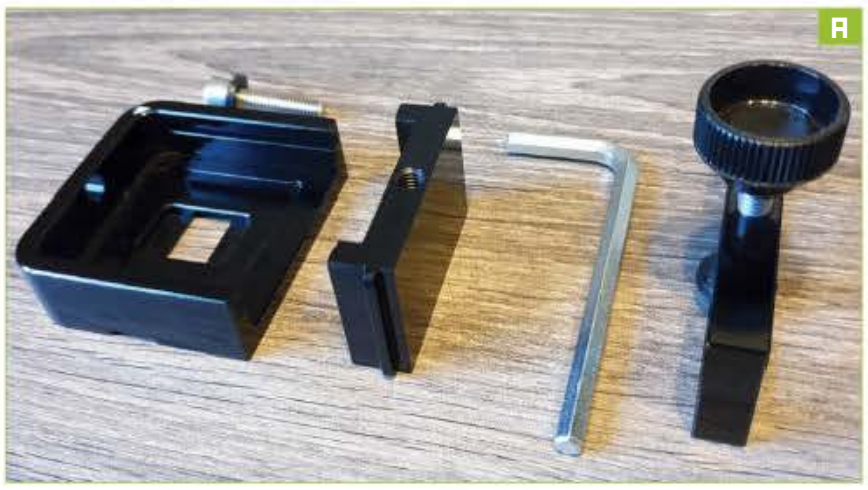
DELIDDING TOOL
($43, for Delid Die Mate, or $102, for Delid Die Mate-X)

LIQUID METAL OR THERMAL PASTE
(Thermal Grizzly Conductonaut, or Noctua's NT-H1). + extras

AH DELIDDING, THAT OLD, TERRIFYING PROCEDURE, usually only recommended for the elite. For the uninitiated, delidding is the act of separating the integrated heat spreader (IHS) from the top of the processor, and then replacing the stock thermal paste that the manufacturer has used with something a little more premium—usually liquid metal or a better thermal paste.

Once upon a time it used to be quite the daunting procedure, involving all sorts of razor blades and torture devices, with a myriad of techniques used to carefully splice your processor away from its IHS, hopefully without damaging the silicon underneath (or yourself for that matter).

For many, it was rarely ever worth it. As temps on the high-end parts remained resolutely below that 70C mark, even with the weakest of aftermarket coolers, the big question was then: "Why bother?" Hell, even when overclocking, it was rare to see temperatures shoot past 75-85C before you hit your silicon limits, especially with a decent AIO cooler. But times changed, and as the core war ramped up processors began to get hotter, as the two kings of desktop computing added more and more cores. It wasn't uncommon to see an Intel Core i7-8700K peak at 75C when under load, regardless of overclocks. And although the company has taken steps to solder some of its higher end parts (the 9000 series, Core i9-9980XE and beyond), for those still stuck on Coffee Lake, or harboring a Skylake-X HEDT chip, delidding offers substantial improvements for both a superior overclocking experience, and far lower temperatures across the board. **–ZAK STOREY**


A

1 CHOOSING YOUR PROCESSOR

First up on the block today is one of Intel's 1151 Coffee Lake processors. We're going to be using the Intel Core i3-8350K for our demonstration chip. It's a fairly well-rounded processor, not too dissimilar from the old i5s of Kaby Lake and prior. Although it doesn't come with a turbo, or Hyper-Threading, it's a fairly sound gaming processor or overclocking chip for any budget tinkerer.

›› For this guide we're going to be showing you how to replace the thermal paste between the chip and the IHS with some of Noctua's NT-H1 TIM instead. The paste Intel uses is typically of poor quality, and with this change you can expect to see temperature improvements ranging from three to five degrees Celsius, dependent on overclock and load application.

›› Liquid metal is the far superior alternative (one we'll be showcasing later), but it comes with an added risk factor as it's conductive, so any spillage on the side of the PCB can cause irreparable damage to the processor.

›› You can effectively reduce your temperatures using liquid metal from anywhere between 8 and 15 degrees Celsius on average, again dependent on clock speed and workload. So let's get started.

2 UNBOXING THE DELID DIE MATE 2

First, unbox and disassemble your Delid Die Mate 2 delidding tool [**Image A**]. In the package, you should find a small CPU retaining holder, a sliding block that fits in it that sits snug against the IHS, a hex bolt, a washer for the bolt, an Allen key, and a clamp.

›› Take all of this apart, and get a good understanding of just how this works. Then, you simply need to drop the processor into the device. To do this, line up the gold triangle on the bottom left corner of the CPU,with the triangle marking on the delidding tool—much like you would install a processor into a CPU socket.

3 REMOVING THE IHS

Next, carefully slide the top IHS remover into the device. There are two rails along the top of the CPU retaining holder that it slides into. Once in, make sure the screw thread and the hole in the retaining holder line up.

›› Secure it in place using the included hex bolt, making sure to keep the washer on the outside of the Delid Die Mate 2. You can do this by hand, and keep going until you can no longer turn it. [**Image B**]

B

» Once you get this far, you'll then need to use the Allen key to pull the IHS remover closer. This will push the IHS off the top of the processor. This does require a bit of force, and can be a bit nerve-wracking as it may make a noise as you do this, but you'll slowly see the IHS move off the chip.

4 CLEAN-UP, AND PASTE APPLICATION

After that, undo the bolt and remove the IHS remover from the device. You should be able to see that the heat spreader has cleanly slid off the processor. Carefully take the IHS off the chip, and remove the processor from the device.

» Once out, use an alcohol wipe or a microfiber cloth and isopropyl alcohol to clean off both the processor and the heat spreader of Intel's thermal paste. Once that's done, you can apply your own thermal paste to the chip. To do this, apply a small dot of paste in the middle of the silicon, and then spread it, either with a paste spreader or an old business card or credit card you no longer use. Make sure you're using non-conductive thermal paste—that way it doesn't matter too much if you make a mess and some spills out onto the green PCB.

» Once that's done, we recommend cleaning up the IHS of all the glue that stuck it down to the chip to begin with. You'll be adding a fresh layer anyway, but by removing the glue residue from the IHS you'll be reducing the total height between the heat spreader and the silicon, and improving thermal performance. I personally use a fingernail to do this, although you can do it with a sharp-edged blade.

5 SECURING DOWN THE IHS

At this point you have two options. You can just place the processor into a motherboard socket, carefully put the IHS back down on top, and then use the motherboard's socket bracket to secure the assembly into position, or alternatively glue the IHS back down and clamp it, so you can swap it in and out of motherboards without worrying later on.

» We like to glue ours back down. To do this we recommend you pick up a heatproof adhesive glue. Here, simply apply a small amount of glue along the remaining glue traces on the CPU itself. Once that's done, reattach the IHS.

» It's important here that you orient the IHS the correct way round. To do this, locate the gold triangle on the processor, then make sure that it's aligned with the bottom left of the IHS's text. Simply place the heat spreader into position on top of the glue traces. If you don't get it right first time, don't worry, simply lift it off and try again, or nudge the IHS into the right position using your fingers.

6 CURING

Once that's done, take the clamp mechanism and carefully maneuver it into position above the CPU. There's a cut-out notch located on the bottom of the Delid Die Mate 2 that the clamp will sit in. Once you've got here, tighten the clamp until it puts pressure on the processor. [**Image C**]

» In an ideal world, we recommend that you leave the glue to cure for 24 hours, just to make sure that the glue is properly set. But, you can probably get away with two to three hours at a push, depending on your glue/patience.

C

SKYLAKE-X, AND LIQUID METAL

When it comes to delidding a Skylake-X processor it's a bit more complicated. For one you're going to need to use the Delid Die Mate-X. This is designed to ensure you don't knock off the RFID chip that sits on the outside the IHS of the processor. However, follow the instructions included in the box, and you'll soon realize that the procedure's almost identical. To apply the liquid metal, attach the hypodermic needle end to the syringe, then carefully push out a small drop of it onto the silicon itself. You don't want too much, as a small amount covers a surprisingly large area, and as this is conductive any spillages onto the PCB are bad news.

If you push too much out onto the silicon, use the syringe to pull the excess back up into it. Start out with as little as you can—you can always add more later. Once you've got what you think is enough, use the included cotton bud sticks to carefully spread it across the silicon. Then it's simply a case of reattaching the IHS in a similar manner to what we did earlier, let it cure, and you'll be good to go.

IS IT ALL WORTH IT?

Well that's ultimately the question to be answered. We've had some impressive results over the years delidding both the Core i7-8086K and the Core i9-7900X. In temperature testing with our Core i9-7900X in Prime95's burn test, we saw stock temperatures of 51C, clocked to 4.4GHz, that increased to 68C. Delidded stock temperature dropped to 40C (an 11C drop), and when overclocked the fall was even more dramatic, going from 68C to 53C (a drop of 15C). With our Intel Core i7-8086K, at stock in Cinebench R15 we saw temperatures skyrocket up to 78C. Overclocked to 5.2GHz it tapped out at 97C with a multi-threaded score of 1,682, and 224 points in single core. Delidded and with liquid metal applied, we managed to overclock it to 5.4GHz, with it scoring 1,753 points in Cinebench R15 multi, and 233 points in single core, with the temperature sat at a comfortable 83C. That's a 200MHz increase, four percent performance increase, and a drop in temperature of 14C.

Even if you're not into overclocking, a more efficiently cooled CPU leads to lower fan speeds and less noise. So for those looking for something to do in lockdown it might just be worth it.

Customize WordPress Blogs with a Theme

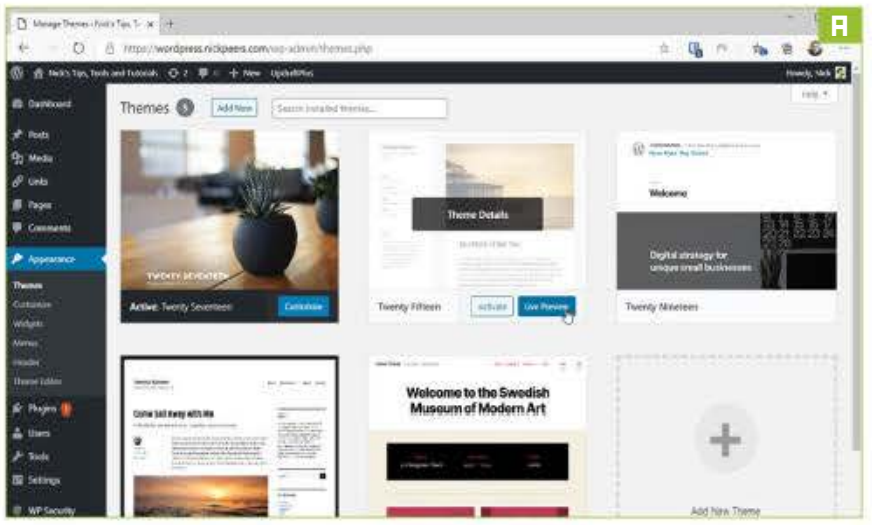
YOU'LL NEED THIS

WORDPRESS SERVER
Any reputable web host will do, or you can host it yourself on your own server.

SO FAR IN THIS SERIES, we've helped you set up your own self-hosted WordPress website, populate it with pages and posts, and protect it in the form of added security and automated backups. With these nuts and bolts in place, it's time to look at your site's appearance.

Content may be king, but if your site isn't easy to read or—sad to say—attractive to look at, you'll put off potential readers. Thankfully, changing the look and feel of your site to match its content is a relatively straightforward task thanks to WordPress's support for themes.

Each WordPress theme is a customizable template of design elements, spanning everything from your page header and menu-bar navigation system to the order your posts are displayed. WordPress provides easy access to thousands of different themes to cover most people's needs. You can install more than one theme at a time, allowing you to try out different themes before settling on one. It's a good idea to read reviews of themes, and look out for themes that are free to install but lock many of their settings behind a paid-for upgrade. **–NICK PEERS**



1 SWITCH THEMES

Log into your WordPress installation and head to "Appearance → Themes." You'll see a list of themes installed as standard with new WordPress installations: 2015 up to 2020. Each has a thumbnail giving you an idea of how that theme looks in action.

›› The theme in current use is marked "Active," and you'll see a "Customize" button next to it—more on that shortly. You can preview another theme by rolling the mouse over it and clicking the "Live Preview" button [**Image A**]. A live preview of your site will be displayed using the theme in question—look for buttons at the bottom to switch between desktop, tablet, and phone view, so you can see how the theme performs on different devices. If you like what you see, switch to that theme by clicking "Activate."

2 FIND YOUR PERFECT THEME

To see what other themes are available, click "Add New." You'll see a selection of featured themes appear. Roll your mouse over one and click "Details and Preview" to read a description and view a basic preview of a dummy post. If you're happy, click "Install" to add it to your collection, or use < and > to compare it against other themes in the current selection.

›› With thousands of themes to choose from, make use of WordPress's search and filtering tools. Start with the keyword search tool: Try words related to your site's content to see if anything interesting comes up. The "Popular" and "Latest" filters are self-explanatory, but the most useful option is "Feature Filter"—click this to apply up to three different filters: Subject, Features, and Layout [**Image B**]. Click "Apply Filters" to view all sites that meet your selected criteria.

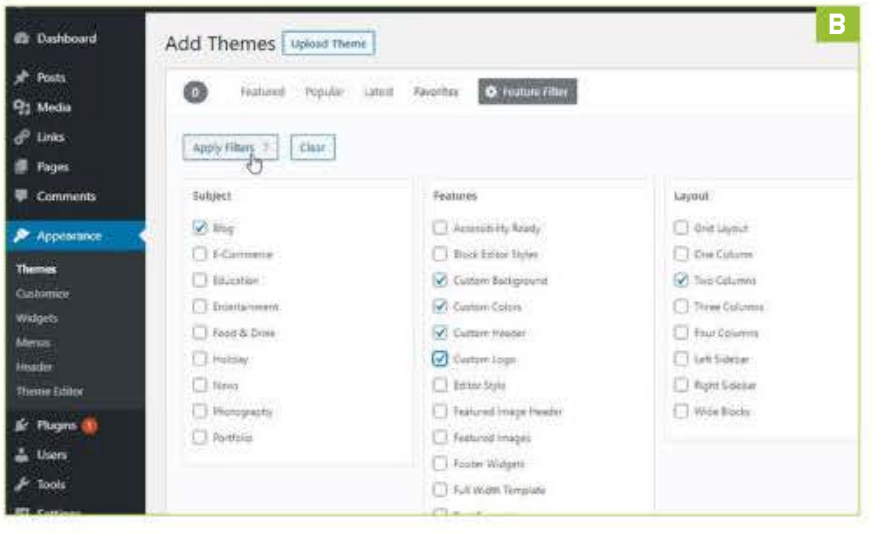
›› You'll also see a "Favorites" option—if you sign up for a free wordpress.org account and then browse themes through the https://wordpress.org/themes/ page, you'll be able to mark them so they show up here. Once you've installed a theme, it'll appear alongside other themes you've installed, ready for a live preview of your site.

3 CUSTOMIZE YOUR THEME

Once your chosen theme activates, navigate to "Appearance → Customize." You'll see the same screen appear as when live-previewing a new theme, complete with a series of options on the left, plus shortcuts to customizable fields displayed on the live preview (look for the blue pencil logo).

›› As you apply changes, you should find that the live preview updates instantly to show you the effects of your alterations. Note that no changes will be applied until you click the "Publish" button at the top of the page.

›› Start with the "Site Identity" section—this is where you can change your site's title and tagline, which appears in the main header. You may also see an option to display a site logo over the header image, plus a site icon to appear on browser tabs and in bookmarks. Other sections focus on different parts of the site's design within the current theme and will vary according to the theme you've chosen.



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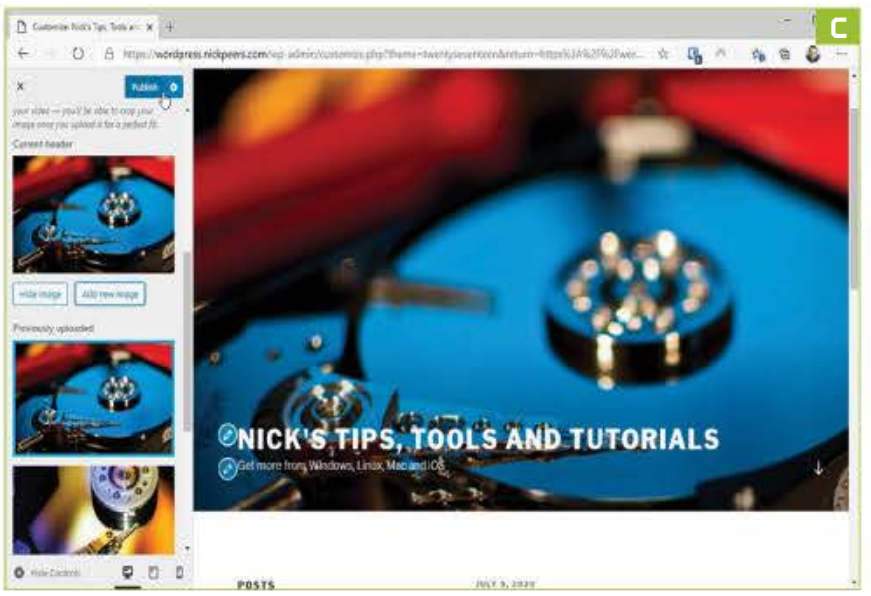


C

Most are relatively straightforward and self-explanatory—for example, "Colors" is where you can set a light, dark or custom color scheme for the site, while "Header Media" is where you upload your own image for your site's header [**Image C**].

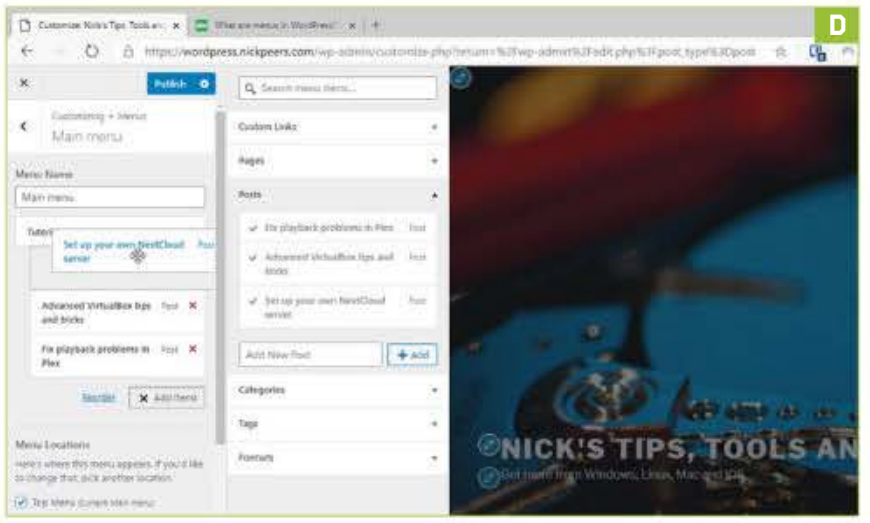
4 BUILD A NAVIGATION SYSTEM

WordPress provides menus as a means of navigating your website. Menus can be a simple list of items for those occasions where you only have a handful of links to share, or you can nest them inside categories to create drop-down menus.

›› If you're currently in Customize view, select "Menus" in the left-hand menu to get started (you can also create and manage menus via the "Appearance → Menus" section). Click "Create New Menu" and give your new menu a suitably descriptive name. Choose where to place your navigation—Top Menu is usually the best spot—and click "Next." Add individual posts, pages, categories, tags, formats or custom URLs via the "Add Item" button, or tick "Automatically add new top-level pages to this menu" to create a menu from any static pages you've created.

5 SET UP DROP-DOWN MENUS

By default, a single-level menu is created, so all items are displayed as individual links at once. This can get quite cramped, so organize your links into individual drop-down menus by "nesting" items inside another. We recommend using categories or tags for your parent item. Add this first, then add the items you wish to include in the drop-down menu. By default, they'll appear alongside the main item, but by clicking and dragging each item on top of the top-level item, you'll see them "nest" inside [**Image D**]. You'll also see a drop-down arrow appear next to the main menu item on the live preview —roll your mouse over this to see the nested items inside, ready for selecting. Once happy with your menu, click "Publish."



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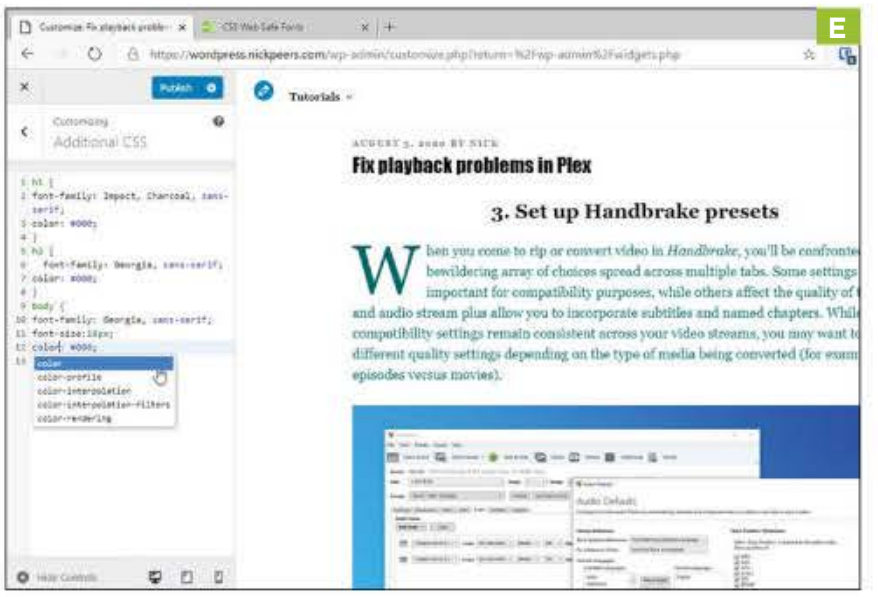

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6 EDIT THE CSS DIRECTLY

If you can't customize your chosen theme to quite how you'd like it to be, and you're reasonably proficient in CSS, then you can change just about any aspect of your site's design. There are several risky ways to do this, but thankfully the customizer tool allows you to incorporate your own CSS styles without breaking your current theme. To do this, head over to "Appearance → Customize → Additional CSS."

›› You'll see a box in which you can enter your CSS styles—it offers both auto-suggestions as you type and syntax highlighting to help you enter your code correctly. Anything entered here overrides the theme's default settings, and you can see the results of your changes through the live preview [**Image E**]. If something goes wrong, remove the code to restore the original settings.

›› Any code you enter here may get lost if you switch themes, so we recommend copying and pasting it into a text editor to store as a backup. To find out more about the basics of editing CSS, visit www.w3schools.com/css/ for a comprehensive set of tutorials and reference guides.

ADD WIDGETS

Widgets enable you to populate your site with small blocks of useful content, which can be placed in various sections, including the header, footer, and sidebars. Select "Appearance → Widgets," where you'll find a large selection of simple widgets, including a tag cloud, search tool, and site calendar to help users view posts by date. On the right-hand side are a list of areas where you can place these widgets—determined by your current theme. Just drag a widget onto one of these, and it'll expand to reveal its configuration settings. You can also manage widgets via the main Customize dialog to see how they'll look on your site—click "Manage with Live Preview" to switch to this view from the main widgets configuration screen.

Additional widgets can be added via plugins—go to "Plugins → Add New" and type "widget" into the keyword search box to see what's available. You'll find both individual widgets as well as widget bundles, such as the SiteOrigin Widgets Bundle. Once installed and activated, go to "Plugins → SiteOrigin Widgets" to see what's available and manage each widget. Any activated widgets can then be added and configured via the "Appearance → Widgets" menu.

Revamp the Start Menu with Open Shell

YOU'LL NEED THIS

OPEN SHELL
And Windows 10.

SINCE BRINGING BACK THE START MENU with Windows 10, Microsoft has tweaked and updated its app launcher numerous times. But if it still doesn't quite hit the spot for you—and if you really miss the old-style Start menu—there is an alternative in the form of Open Shell.

This free app brings back the pre-Windows 7 Start menu, giving some retro flavor to your PC. Open Shell gives you lots of different styles to play with, includes several different Start button options, and can even tweak other elements like the taskbar. It spun off from Classic Shell, which ceased development in late 2017. You can still download Classic Shell, but it is better to stick with Open Shell since it is actively updated by a team of developers.

Settings are organized into two rows of tabs at the top of the program, each containing myriad options to tweak and tune (make sure you click "Show all settings" to display extra tabs). If you're not sure where to find a setting, there's a built-in search box as well. With so many settings available, Open Shell is a great way to add visual flair to your Start menu. **–ALEX BLAKE**

1 DOWNLOAD AND INSTALL

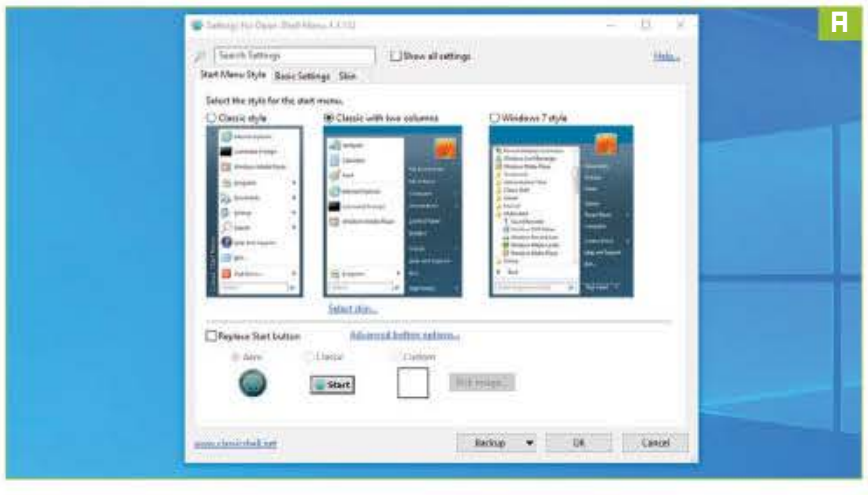
Open Shell is hosted on GitHub, a repository of code and various apps and tools. Go to the project's home page at https://github.com/Open-Shell/Open-Shell-Menu, scroll down to the "Download" section, then click the download button. On the next page, click the EXE file in the "Assets" section to download the installer. Once you've done that, run the installer file and follow the on-screen instructions to install Open Shell.

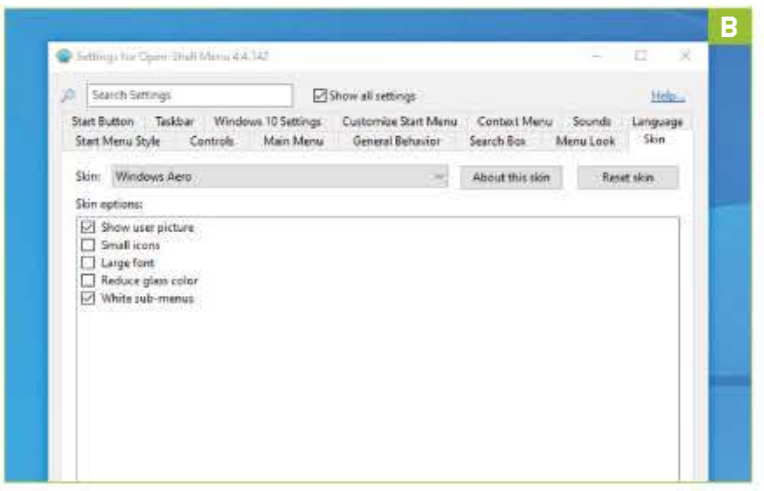
›› Upon clicking the Start menu, you'll notice it has automatically changed to the old-style menu. Gone are the Live Tiles, replaced by a much more compact menu reminiscent of the days of Windows 7 and before. If at any time you want to temporarily switch back to the Windows 10 Start menu, click "Start Menu (Windows)" at the top of Open Shell's Start menu. If you are happy with things as they are, there is no more you need to do. However, Open Shell has a lot of customization tricks up its sleeve.

2 SET A START MENU STYLE

In the Windows 10 search box, type "Open-Shell Menu Settings" (the hyphen is important) and click the top result. This will open on the Open Shell settings manager, with the "Start Menu Style" tab open and the "Windows 7 style" option chosen by default. Click either "Classic style" or "Classic with two columns" to try a different look [**Image A**]. Your changes will be applied.

›› As well as the menu itself, you can also alter the appearance of the Start button. You can change it to the Open Shell logo, the classic Start button (with text and the Open Shell logo), or a custom design of your choice. If you want to use the third option,





click "Custom," then click "Pick image..." and locate the file you want to replace the Start button with (transparent PNG image files work best).

3 ADVANCED APPEARANCE CONTROLS

One of Open Shell's main strengths is its ability to let you get really stuck in. The app gives you deep controls over the appearance of various elements, such as the Windows 10 search box, icon sizes, and more.

›› In the Open-Shell Menu Settings window, click the "Skin" tab. The default option in the drop-down menu is "Metro," mirroring Microsoft's design language of the same name. Other options include "Classic Skin," "Metallic," "Midnight," "Windows 8," and "Windows Aero" [**Image B**]. You can also remove the skin styling entirely by clicking "←No Skin→." When you choose one of these options, you can customize it further in the "Skin options" box, which allows you to make the menu opaque, increase the font size, use small icons, as well as other options.

›› Next, click the "Menu Look" tab. Here, you can tweak settings in detail. There are options for changing the sizes of small and large icons, adjusting the Start menu's animation when you click the Start button, whether font smoothing is used, sub-menu scrolling speed, plus more.

›› If you want to add or remove a button from the Start menu, click the "Customize Start Menu" tab. Click the name of an item in the resulting list, and you can replace it with something else. Alternatively, you can click an entry

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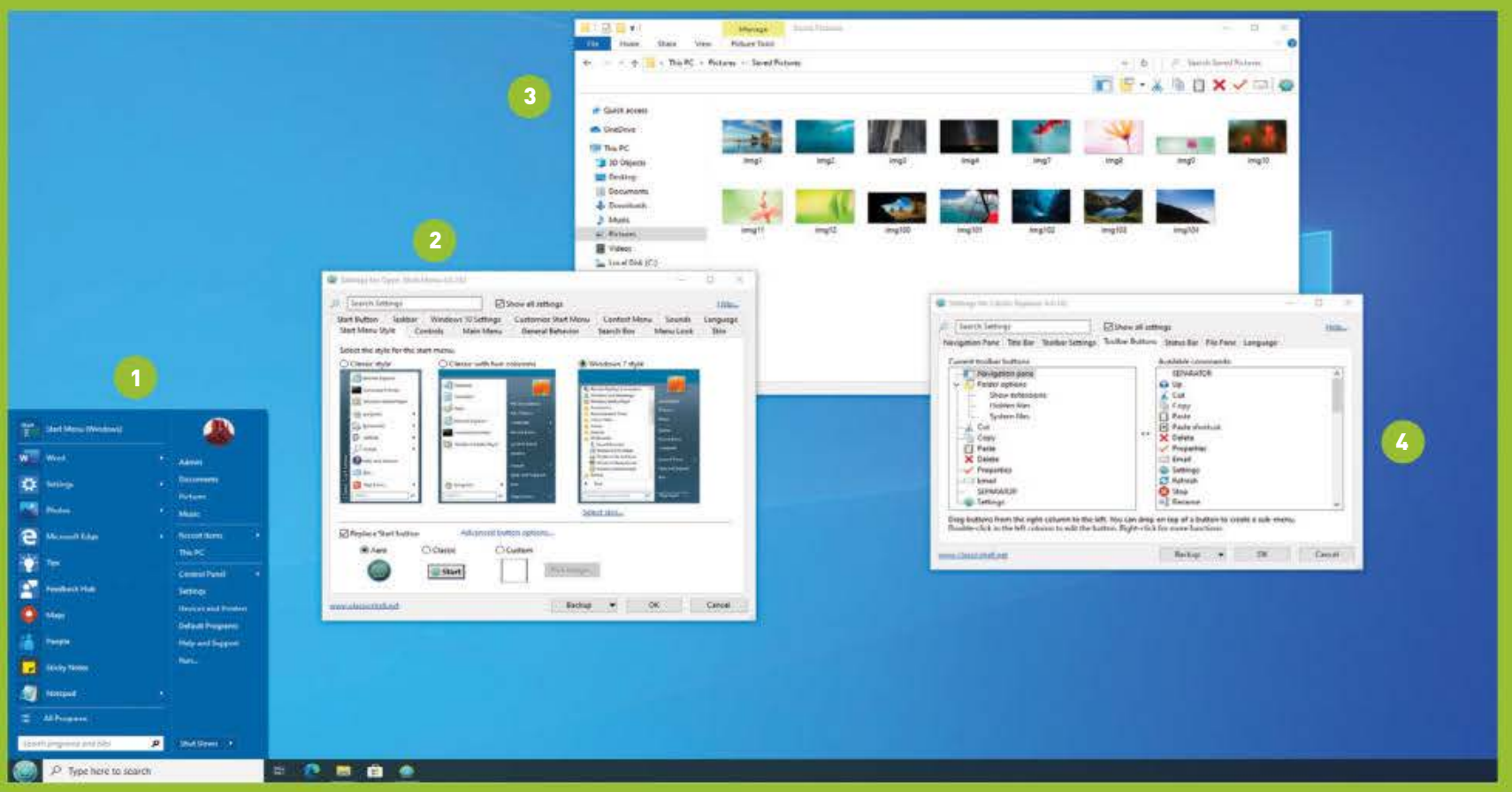
ADJUST WINDOWS TO YOUR LIKING



1. There are three main Start menu styles to choose from, including Windows 7 style, Classic style, and Classic with two columns.

2. Open Shell has a whole host of options to customize your Start menu. Tick the "Show all settings" checkbox to see them all.

3. Open Shell can also change the visual style of Windows Explorer. Click the logo in the top-right corner to access its settings.

4. The Windows Explorer Settings window contains useful tweaks, including changes to the status bar, file paths, toolbars, and more.

in the "Display" column to change how it appears; choose between showing an item as a link, as a menu, or hiding it altogether.

» In *Maximum PC*'s September issue we discussed how to change your taskbar's appearance with TaskbarX. Open Shell can implement similar visual changes to the taskbar. In the "Taskbar" tab there are options to toggle between an opaque, transparent, or glass-effect taskbar (like in TaskbarX). You can also change the taskbar's opacity, color, borders, and add a texture overlay.

4 ALTERING BEHAVIORS

Open Shell goes beyond the visual—it offers ways to change how elements of Windows 10 behave, too. In the Open Shell Menu Settings window, click the "Controls" tab. This tab governs what happens when you click the Start button, either with the left mouse button, right mouse button, or a combination of mouse and keyboard. For instance, Shift-clicking the Start button opens the standard Start menu instead of the Open Shell variant by default.

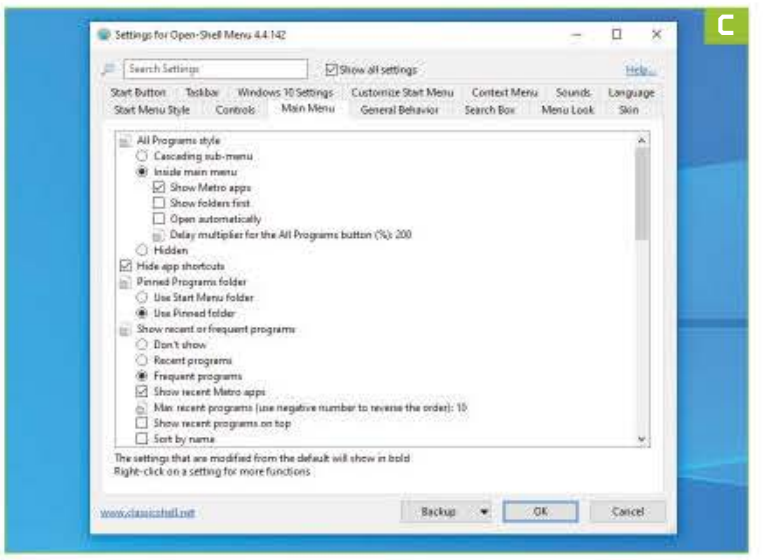
» As for the behavior of the Start menu itself, that can be tweaked in the Main Menu tab [**Image C**]. This is useful if you want to hide the list of recently used programs, for example, or reverse the alphabetical sorting of apps. There are a lot of options in this tab, giving you a deep level of customization that is not normally possible using the built-in tools in Windows 10.

» Settings that alter how the search box on the Start menu behaves are (unsurprisingly) located in the "Search Box" tab. This provides a raft of deep-level settings at your fingertips. You can specify what you can search for and where Windows will look on your PC, toggle auto-complete on search queries, or hide the search box completely for a cleaner look. Note that this does not hide the search box on the taskbar, only the one on the Start menu.

» Even the right-click menu gets its own group of settings in the "Context Menu" tab. This lets you remove certain options from the context menu—such as browsing to a program's location in Windows Explorer—or hide the right-click menu entirely (this only affects Open Shell and does not disable the context menu elsewhere).

» Fancy adding some audio effects to your Start menu? The "Sounds" tab lets you do this, enabling you to play sounds when you hover over the Start button, for example, or open a sub-menu.

» Finally, miscellaneous settings can be found in the "General Behavior" tab. For example, if you want to toggle whether newly installed apps are highlighted, or change the delay before tooltips appear, this is the place to go.



BUILD IT

ZAK STOREY, EDITOR

Air Supremacy

Building the perfect home office PC (with a touch of 4K gaming)

LENGTH OF TIME: **1-2 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

HELLO! Well first off let me welcome you to our first ever build-it seen through the eyes of the person who actually does the building. Oh this feels good. Too many years have we toed and froed over whether or not to commit to this literary device, and yet here we are. The logic is simple: There's a picture at the top denoting who built the rig (today, me), but in this section the builder still refers to themselves exclusively in the plural (our, us, we). Well today I've had enough, and have used my limited executive Editor power to decide that build-it can and will be experienced through the builder's personal perspective. It sounds trivial, but it's time for a fresh lick of paint for these wistful articles of ours. Anyway enough of that waffle and on to the good stuff. Namely the build.

Now for the last few months I've been teasing the fact I've wanted to piece together a new system for myself. I've long had the 4K gaming monster as my home working machine, but as I game less and less, and can't justify the 12-core processor sitting at its heart, coupled with those twin heat-producing RTX 2080 Supers, it's become more of a burden than a boon in my office. The heat produced by those components and then exuded so efficiently by the cooling system effectively turns my WFH life into a sweatbox (I'm not so fortunate to have AC at home). So to that end, and because I'm trying to reduce the number of hours I spend in game (sort of), I've decided to go for something quite radically different to what's usual here in the mag. And if I'm honest, the result is incredible.

PACKING HEAT

THE BIG THING with this build is the case—the Hydra Mini in black. This is a bespoke chassis made by a small company in Italy and constructed from a single sheet of stainless steel, which is then powder-coated in matt black, white, or clear-coated with a satin finish. It's then perched on top of four aluminum feet. It looks sublime: It's simple, elegant, and open-air, meaning I can swap out parts as and when I need to for testing, and as far as cooling is concerned, there's certainly enough access to airflow.

That said, it does have drawbacks: It's made in Italy, so shipping takes a long time; you are going to have to clean it more; and there's no front I/O outside of the DimasTech power switch. On top of that, it has a flipped design, with a PCIe riser cable, so the GPU is situated in the back, and everything else is in the front. That leads to some cable-management issues, both during the build and after.

For other components, I've gone with an Intel Core i5-10600K, 16GB of Corsair Dominator Platinum RGB memory with a C16 latency (if you go for C18, it drops the price by $70, by the way), a 2TB Samsung 970 Evo Plus for storage, a Zotac GeForce RTX 2080 Super AMP Extreme, a 750W Corsair SFX PSU, complete with a mix of stock and pro cables, and perhaps the most controversial pick of the lot, a Noctua NH-L9i Chromax Black CPU cooler.

Why so controversial? It's a 92mm low-profile CPU heatsink. It's very good, but it's only rated to cool up to 95W of TDP, which is enough for a Core i9-9900K at stock, but Comet Lake is hot, and the 10600K clocks in at 125W, or 95W in a "configurable TDP-down" mode, something you can only configure if you're an OEM manufacturer. So it is going to be enough? It's time to crack out the screwdrivers, grab that hobby knife (yep), and get to work.

INGREDIENTS

PART		STREET PRICE
Case	Hydra Mini Black Expanded Bundle	$111
Motherboard	Asus ROG Strix Z490-I Gaming	$293
CPU	Intel Core i5-10600K	$263
GPU	ZOTAC GeForce RTX 2080 Super AMP Extreme	$700
Memory	16GB (2x8GB) Corsair Vengeance LPX DDR4 @ 3600	$320
PSU	750W Corsair SF750W 80+ Platinum	$185
Storage	2TB Samsung 970 Evo Plus	$350
CPU Cooler	Noctua NH-L9i Chromax Black	$80
OS	Windows 10 Home 64-bit OEM	$24
Total		$2,326

1 SOME ASSEMBLY REQUIRED

SO HERE'S A FIRST LOOK at the Hydra chassis. This is what comes in the $111 bundled edition. You can buy the kit without the PCIe riser cable, and that'll set you back just $77. So you get that swanky PCIe riser, complete with Hydra branding, the rear GPU bracket that you need to attach yourself, a bag filled with motherboard-standoffs, hex screws, and a couple of Allen keys of varying size, the DimasTech power switch, and of course the frame itself. It all comes well packaged and protected, and arrived without any problems.

You will need to attach a few things during the installation process, although I'll cover that more in detail in the later steps.

2 STAND TO ATTENTION

THE FIRST THING to do with the case is install the GPU mounting bracket and motherboard stand-offs. In the bag of screws are six stand-offs for the motherboard. The average ITX board will support four stand-offs. Locate where these are going to be on the chassis for the board, and carefully screw them into position by hand. I recommend doing it this way to not damage the thread.

Remove the rear GPU bracket from its packaging, and using two of the thicker Allen screws, secure it in position using the Allen key provided. Make sure you install it the correct way round. The bracket has slots for the PCIe card to sit in to support it. Position it so the GPU ports are facing where typically the front of a chassis would be.

3 MOTHERBOARD PREP

AND HERE WE HAVE the first shot of our ITX Z490 motherboard of choice. Now yes, it is expensive: At $293 it's one of the more pricey Z490 boards out there, but it comes packed with features—from support for two M.2 PCIe SSDs, to a bevy of connectivity on the rear, an integrated VRM cooling fan, and what's perhaps the best looking rear I/O cover on the market to date.

Here you can see I'm installing the Core i5-10600K into the socket in the traditional method. Lift the bracket up, identify the gold triangle, line it up, drop it in, secure the bracket back down, plastic cover pops off, done.

4 IMPRESSIVE DESIGN

THE ONE THING that almost justifies the ridiculous cost of this mobo is the level of design baked into it. What you're looking at isn't some add-in card, or something thrown in the box, rather it's the audio-componentry/M.2 slots/chipset heatsinks deconstructed. That front-most layer houses both the audio parts and two M.2 PCIe SSDs, both covered with two passive heatsinks with thermal pads. On top of that sits the RGB heatsink/cover. All of these have bespoke interconnects to ensure it all connects to the motherboard, or out to the audio ports. Neat huh?

Whether this neat design holds up in testing, especially with Samsung's fastest PCIe 3.0 drive, remains to be seen.

7 SIMPLICITY IS SOPHISTICATION

MINIMALISM IN SYSTEM-BUILDING is a big part of my ethos and style, and I often rip out the front I/O. In my eyes, it's just not that useful, as I can plug anything in the back. Hydra clearly agrees, as the Hydra Mini comes with a sole power switch and nothing else.

The switch made by DimasTech is a simple yet beautiful button that comes with a white LED ring. Behind you'll find two black-sleeved cables, one to connect to the power button header on the board, the other to connect to the power LED header. To install, unscrew the retaining nut, thread the cables through the power-button cutout in the case, then reinstall the retaining nut from the other side.

8 MOTHERBOARD ONBOARDING

WITH EVERYTHING on the board, it's time to install it all on the Hydra Mini. This is trickier than you might think. Because the case is not exactly symmetrical and doesn't have four square sides, you can't really lay it on its back. So you have to prop it up with a couple of small boxes to get a flat, level surface. But once you've done that, you know the drill. Place the motherboard over the stand-offs, then secure it down using the included screws. Only one slight annoyance is the fact they are Allen screws again, so you'll be using the included Allen key.

I struggled getting the bottom left one in, as I couldn't screw the stand-off all the way into the Hydra Mini, so it was slightly off the mark. A bit annoying, but three screws is plenty to hold this in place. To rectify that problem I'd need to attack the standoff with a set of needle-nose pliers, but that may damage the thread.

5 PREMIUM PRODUCT

EVER OPENED A NOCTUA BOX BEFORE? The company has made a name for producing some of the best air-cooling tech out there, and the way it presents that to the end user is exceptional. Open the Chromax NH-L9i box and you're greeted with the 92mm cooler center stage, its four mounting screws, a low-noise adapter, a tube of my favorite Noctua NT-H1 thermal paste, and a stick-on metal Noctua badge in that brown and silver styling.

As for installing? Well, place a dot of the paste on the center of the processor, line up the cooler with the mounting holes on the mobo, and attach it from behind using the four screws included in the box. No backplate, no messing around. For an AMD rig you'll need to pick up a separate version of the cooler (NH-L9a).

6 "SNUG" MIGHT BE GENEROUS

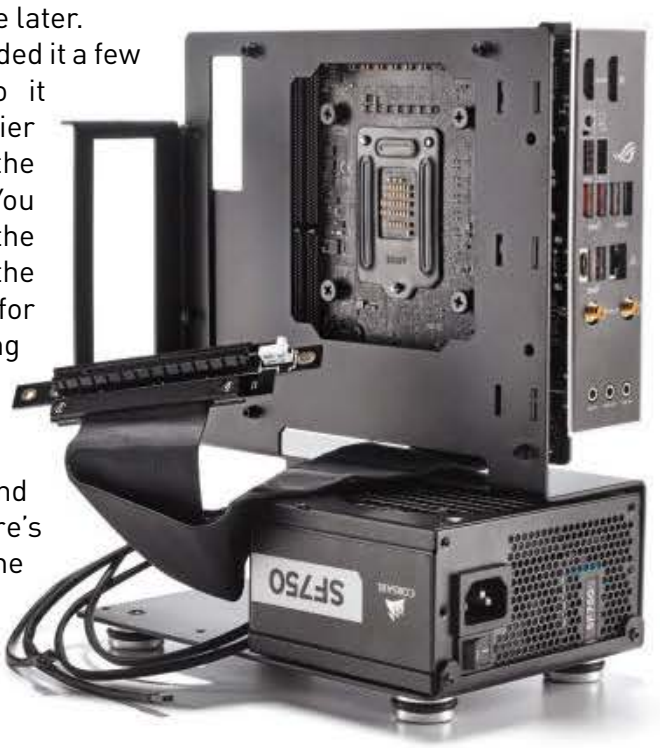
I FOUND THE BEST WAY to get the cooler properly installed on the Z490-I is to remove the actual fan from it first. The L9i will only fit one way on the board, and it's very snug. Once that's installed, reinstall the fan. Next you need to run the cable to the top CPU fan header. It's not that easy, especially if you want to keep it looking clean. I cut the fan cable's heatshrink that's closest to the fan (bottom right corner in the picture) to get access to the four thin fan wires, then routed that down the side of the heatsink, so it was flat up against the memory, then double-tucked the sleeved cable under the heatsink and next to the first DIMM slot. I then ran that cable along to the top of the DIMM, underneath a part of the VRM heatsink, and cut the heatshrink at the end, so I could plug the fan cable into the header without it looking contorted.

To cut the heatshrink, use a hobby knife and cut around the heatshrink on the cable, making sure not to cut into fan cables. Fold it out, and use a pair of scissors to snip off the excess.

9 FOLDING, FOLDING, FOLDING

SO HERE'S A FIRST LOOK at the back of the Hydra Mini. There's not a lot of space to work with. You've only got limited room to install your SFX power supply, and you have to install it with the fan facing upwards, of course again with the two Allen screws. You'll also notice I've installed the PCIe riser cable here too. Or at least sort of. There's actually nothing that it mounts to, you simply move the white slider back on it, attach it to your card's PCIe connection, and then lock it in place. Now at first glance, that sounds terrifying, but I'll explain why it's not that bad a little later.

I've also folded it a few times just so it sits a little tidier underneath the back there. You can also spot the cutouts in the Hydra Mini for cable ties along the back near the I/O plate. These come in handy later, and of course there's the slot for the 24-pin power top left.



10 OH, THE HUMANITY!

I DECIDED IT WAS BEST to do a dry test-fit of our GPU. It's the same RTX 2080 Super that we used during our Comet Lake gaming build with the Core i9.

The GPU get its support entirely from that GPU bracket. You slot the card into the bracket, the rear I/O of your GPU has two notches that slot into cutouts in it. Then a single screw secures it at the top, and that's it. It doesn't look that secure, but when you think about it, it's more than enough to hold the heavy bulk of that thing in place. Only problem? It's in the way of about 90 percent of my cable management routes. So yep, out it comes again, and it's an Allen screw too.

11 CABLECOPIA

FOR POWER SUPPLY CABLES I'm using a combination of the stock cables that came with the SF750, and a set of Corsair's Pro cables, because the majority of the stock cables are still locked up in our main office. I'm using a short 24-pin cable, then the long, eight-pin PCIe Pro cables, and eight-pin EPS cables.

As cable management room is slim at the back of the Hydra Mini, I've wrapped the cables up into coils, then connected them to where they need to go and bunched the excess cable underneath this cubby hole or PSU cover. Then I've installed the graphics card, and attached the PCIe riser cable to it, and then cable-tied multiple sets of cables together to give it some rigidity.

12 BUILD COMPLETE? MAYBE

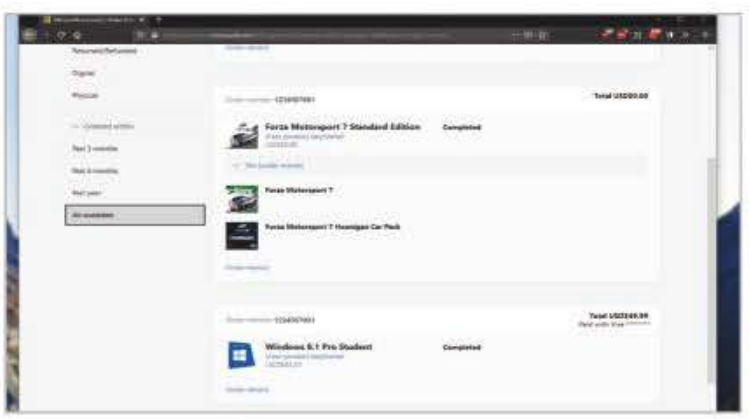
AND HERE IS the build finally completed. You can definitely tell it was designed for short cables, as that's what this really needs (fortunately most SFX PSUs feature short cables anyway). If you want to go the extra step, I'd recommend picking some up from the likes of CableMod. If I'm honest, it's one of the few things that bugs me about the build.

Additionally, you'll notice that the Corsair SF750 power supply's white specs label is showing through the bottom near that Hydra logo cutout, and that's really annoying. I may just get a small piece of black Perspex to cover that up. But otherwise the system looks darn fine.

13 WIN10 ACTIVATION

THIS IS PART OF THE REASON WHY it's so handy to have a Windows 10 license attached to a Microsoft account. If you need to activate Windows 10 on a new PC and already have a license tied to your account, you can do this either during the install if you have internet, or in my case, since the system had no internet connectivity during the install process, after you've logged in with a local account.

Hop over to account.microsoft.com, sign in, click "Payment & Billing," then hit "Purchase history." Once you've found your old license order, there's a button that says "View product key/Install." Click that, and it'll bring up your Windows key, then click the Windows menu button on your taskbar, type "Activation", go to the activation page, and update your product key. Bear in mind that you can only use/have one machine at a time with your Windows 10 license activated on it.



14 HAPPY DESKTOP, HAPPY LIFE

WITH THAT OUT OF THE WAY, and all my drivers and programs installed and updated, I got to work on customizing my desktop. I keep things fairly clean. During system setup, the first thing I typically do is remove the Recycling Bin, and replace it with Minibin. Minibin is a free program developed by e-sushi. This adds a little icon to your notification bar in the bottom right, which enables you to access your Recycling Bin. You can then hide your Recycling Bin icon on the desktop by right-clicking the desktop, selecting "Personalize," then "Themes" on the left bar and "Desktop icon settings" on the right.

I then usually add a few Rainmeter widgets (which we can't show for legal reasons). Rainmeter's a lightweight desktop customization program with thousands of skins you can use for free. I typically use one of the clocks from mnmlUI by Khanhas and a CPU temp display as well.

1 **The one thing this build needs desperately is some custom cables, with cable combs. A bit of color here would really make it pop, and the combs would help give it a bit more form.**

2 **There is room to upgrade the fan if you want to. The default fan on this cooler is a slim 92mm variant, Noctua sells a full-fat 25mm thick fan that adds about 15 percent extra static pressure.**

3 **Getting a slice of black Perspex or card to hide the power supply sticker here is a priority right now. Alternatively, you could add some lighting down there too. Oh that's tempting.**

4 **16GB of memory is less than half of what I'm used to for my home machine, hopefully it'll be enough for my new game-free aspirations.**

THE PERFECT BUILD (FOR ME)

THIS IS ONE of my favorite builds of all time. The Hydra case is a ridiculously affordable ITX chassis that has such potential. I've seen liquid-coolers do crazy things with this, albeit with significant modding, and even as a stock build it looks impeccable. There isn't official support for AIO liquid-coolers or radiators on it, but you could prop one up to the side, or drill some holes in the Hydra Mini and make your own bracket for one.

Combining the Corsair Dominator Platinum RGB memory with the Asus ROG Strix Z490-I Gaming motherboard and that black Noctua cooler gives it a stealthy vibe, and works well with the subtle lighting elements. When configured, it's very classy. The Capellix LEDs in the Corsair memory are seriously bright, and the swathe of RGB baked into the GPU around the back is acting as a sort of ambient backlighting.

The build process was fairly seamless. I had no major issues at all outside of how to route the CPU fan cable. And that was more just me being stubborn than an actual problem. I could've just installed the cable at the top right of the machine, but then I'd have been left with an unsightly loop.

So what would I change? Well for starters as much as I love the Zotac card, it's no doubt going to have to go back to Zotac at some point. To that end, I'll be swapping the card out for one of the EVGA RTX 2080 Supers found in the 4K Gaming PC from last December. Reassembling that cooler may take some time, but it will give me the perfect card for my 3440x1440 screen. The only concern here is that the XC Ultra Gaming is a triple-slot card (despite having a smaller cooler than the Zotac). Officially the Hydra only supports dual slot because of the size of the bracket. I may also ditch the SF750 power supply for the Silverstone Strider 800W, as that has custom-sleeved, short, black and red cables.

As for performance, most results fell in line with what I expected from the components at hand. The more interesting element is the temperatures, especially with that 92mm heatsink. Idle temps sit around 40-45C after a day's work. Under load that goes up to around 80-90C at stock—but we're talking serious load. To get around that (although it's still 10C from TJMax), I've offset the CPU VCore voltage using Intel's Extreme Tuning Utility by -0.04V, and dropped the max turbo frequency to around 4.3GHz across all six cores, (4.7GHz on two cores) and that's dropped temps to just over 80C at the top end.

It's whisper-quiet at idle. At a fixed 40 percent RPM until 75C, that Noctua is inaudible, and when not under load both the GPU and the PSU fans don't spin at all.

This is a stellar machine, super-silent, gorgeous, and perfect for anyone who's looking to build a ridiculously small, slick home office PC that's a bit different.

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	3,218	1,350 (-58%)
CrystalDisk QD32 Sequential Read (MB/s)	4,889	3,536 (-28%)
CrystalDisk QD32 Sequential Write (MB/s)	4,168	3,169 (-24%)
Middle Earth: Shadow of War (fps)	94	55 (-41%)
Total War: Warhammer II (fps)	82	47 (-43%)
Assassins Creed Odyssey (fps)	42	36 (-14%)
3DMark: Fire Strike (Index)	33,086	22,306 (-33%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an AMD Ryzen 9 3900X, 32GB of DDR4 @ 3200, 2x EVGA GeForce RTX 2080 Super XC Ultra Gaming, and a 1TB Corsair Force MP600 M.2 PCIe 4.0 SSD. All tests were performed at 4K with the highest graphical profile.

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Corsair One A100

Return of the king

OUR FAVORITE compact desktop PC is back! The Corsair One returns with, at first glance, no discernible changes. The solid metal case is exactly as we remember it—a thin tower with a tiny square footprint, gunmetal gray, with two tasteful RGB strips inlaid down the front. But this isn't the same machine we've seen and loved before; this Corsair One is a traitor to its kin, because inside that outer shell is an AMD Ryzen processor.

You might've guessed this already from the name: "a" for AMD, much like the Intel-powered One models use 'i'. The processor in question is a Ryzen 9 3950X, a 16-core beast of a chip that currently occupies the top of the Ryzen pecking order. When it comes to gaming, AMD finally has a Ryzen chip that can compete with Intel's similarly powerful offerings.

This isn't a Pro version of the One, so as per Corsair's modus operandi it's a more gaming-oriented system. That's not to say that the processor and graphics card can't handle workstation-level tasks; all it really means is a relatively conservative 32GB of RAM and a slightly smaller power supply. A Ryzen-powered One Pro has yet to be announced, but we wouldn't be surprised to see one. The a100 is simply better suited for hardcore gaming; that being said, Nvidia's new studio drivers are always an option.

As it stands, the RTX 2080 Ti inside this micro machine comes with Nvidia's "Game Ready" drivers, and it unsurprisingly kicks ass at gaming in any resolution. 4K Ultra is definitely an option here, with frame rates around 60fps in demanding AAA titles, although twitch-shooter fans may want to turn it down to 1440p or even 1080p to guarantee 100+fps. The Ryzen processor holds up well in CPU-bound games too, as seen by its excellent performance running *Total War: Warhammer II* at 4K Ultra.

CPU performance is strong in other areas too, with 32 threads working hard to handle rendering and encoding workloads. Both components run cool thanks to Corsair's dual liquid-cooling system, which dissipates heat through two radiators on opposite sides of the case. The interior layout hasn't changed from previous models; it's still incredibly compact, with a flexible PCIe riser that allows for the GPU to be mounted upright and a single 140mm fan at the top of the case. The upper grille gets hot at times, but the core system temperatures rarely rise above 50C.

That intelligently designed interior does have one key drawback: Upgrading any Corsair One will likely prove a difficult and arduous process. Memory and drives should be straightforward, but getting the case open properly is challenging enough, and swapping out the GPU will require some serious water-blocking dexterity. Fortunately, the a100 is certainly future-proofed; even with rumors circulating about Intel Xe and RTX 3000 GPUs, the hardware inside this machine will be usable for years to come.

Perhaps the most interesting addition to this One is PCIe 4.0 support, coming with the new Ryzen processor and the custom-made X570 ITX motherboard. The a100 comes with a 2TB HDD to bolster its storage capacity but boots from Corsair's own 1TB Force MP600 SSD, a 4th-generation NVMe drive that offers transfer speeds close to 5GB/s. That's a performance improvement of over 40 percent compared to the 3rd-gen drives found in the a100's Intel counterparts.

The a100 does share one critical Achilles' heel with its predecessors: the price. We've got the top-spec model of this Ryzen machine, which clocks in at an eye-watering $4,000. Two cheaper models are available at $3,600 and $3,000, the cheapest model dropping down to a Ryzen 9 3900X and an RTX 2080 Super. It's still an impressively powerful machine, and the systems are identical save for the CPU, GPU, and drive capacities.

Even with the price tag, we can't help but love every version of the Corsair One, including its Ryzen child. Simply put, the a100 is an absolute joy to play games on. Setup takes no time at all, and the compact case means that even a small desk nook becomes a viable gaming space. If you're a supporter of Team Red, this could be the gaming PC for you. **–CHRISTIAN GUYTON**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	2,178	3,783 (74%)
CrystalDisk QD32 Sequential Read (MB/s)	3,136	4,969 (58%)
CrystalDisk QD32 Sequential Write (MB/s)	2,126	4,270 (101%)
3DMark: Fire Strike Ultra (Index)	6,988	8,662 (24%)
Total War: Warhammer II (fps)	42	60 (43%)
Tom Clancy's The Division 2 (fps)	38	56 (47%)
Metro Exodus (fps)	37	55 (49%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of an an Intel Core i9-7900X, 32GB G.Skill RipJaws V series DDR4 @ 3,000, an MSI GeForce GTX 1080 Ti Gaming X, and a 512GB Samsung 960 Pro PCIe SSD. All tests performed at 4K at the highest graphical profile. Metro Exodus tested at 4K at High.

VERDICT
9
KICK ASS!

Corsair One a100

ONE Awesome gaming performance; super fast SSD; compact footprint.

ZERO Hard to customize; very expensive.

$4,000, Corsair.com

SPECIFICATIONS

CPU	AMD Ryzen 9 3950X
Graphics	Nvidia GeForce RTX 2080 Ti
RAM	32GB (2 x 16GB) Corsair Vengeance LPX DDR4 @ 3,200MT/s
Motherboard	Asus Prime X570 Pro
Primary Storage	1TB Corsair Force MP600 M.2 NVMe SSD
Additional Storage	2TB 5400RPM HDD
Cooling Solution	2x Corsair One AIO Cooler (CPU & GPU)
PSU	600W Corsair SF600 80+ Gold
Case	Corsair One
Warranty	Two years

The RGB lighting syncs to compatible games via Corsair's iCue software.

The Blade Pro 17's 4K touch panel is beautiful to behold.

Razer Blade Pro 17

The Blade is back to blow you away

WE SHOULD STOP reviewing Blade laptops, because we never want to give them back. The Blade Pro 17 is no exception; just a few days with this laptop and we're already in love. We've got the top-spec model of the Pro 17, which comes with a gorgeous 4K touchscreen at 120Hz, ideal both for gaming and creative endeavors.

This particular Blade retails at an eye-watering $3,799.99, but you definitely get a lot of bang for your buck. The processor is a shiny new 10th-gen Intel Core i7 chip, the 10875H—a speedy eight-core mobile CPU with 16 threads thanks to Intel's Hyper-Threading technology. Backing that up is 16GB of SODIMM memory and an Nvidia RTX 2080 Super with 8GB of video memory, and a Max-Q design that makes it smaller and less power-hungry.

Yes, the Max-Q models of the GeForce Super cards are here, and Razer was quick to take advantage. Although beefy gaming laptops are capable of running the regular 2080 Super at its recommended 115W TDP (or even higher), the TDP for the 2080 Max-Q is a mere 90W. The processor TDP is also just 40W, meaning that this system squeezes a lot of performance out of very little power. The Pro 17 also doesn't run as hot or loud as many previous Blade models, but this could be due to the larger chassis and vapor chamber cooling solution.

Obviously, this laptop is still a chunky unit. That 17-inch display means that the Pro 17 is more than 15 inches wide—too large to fit in the average laptop bag. While the chassis is impressively thin for such a powerful system, it's also too heavy to comfortably carry around on a daily basis. If you're after something that can occasionally be lugged to a friend's house or on holiday, it's fine; if an eminently portable gaming platform is what you're after, you may be better off with the smaller Blade 15.

As a semi-portable desktop replacement, though, the Blade Pro 17 dominates. Physical connectivity is king, with a selection of ports that would put some mid-tower PCs to shame: Everything from Thunderbolt 3 via USB-C to HDMI connectivity, and a UHS-III SD card port that's ideal for photographers. Connect a mouse and a second display and you've got a perfectly competent desktop setup for either gaming or professional creative work.

Of course, that would all mean nothing if the performance wasn't there. Thankfully, the Blade Pro 17 doesn't just come to play: While the RTX 2080 Max-Q doesn't quite perform as well as its more powerful originator, it still comfortably powers through rendering tasks and can play most games at 4K (if not at 60fps Ultra). Dropping the resolution to 1440p in games guarantees good performance in all but the most GPU-battering titles.

The 1TB NVMe SSD isn't anything to write home about, but it provides plenty of storage at the high transfer speeds we've come to expect from premium laptops. It's upgradable, too; there's an extra M.2 slot for a secondary drive here, and the memory can be replaced with any compatible SODIMM kit up to 64GB.

The rest of the features on show here are nothing new for the Blade product line, but are still welcome. The addressable RGB keyboard looks great, and the keys have a decent amount of travel, although the keyboard is somewhat squished into the center in favor of the two mighty Dolby Atmos speakers that surround it. The trackpad is still enormous and very responsive, although the touchscreen is great for quick swipes and clicks.

Battery life is, of course, the last hurdle where the Pro 17 falls down. Playing *Apex Legends* continuously from full charge netted us less than two hours of playtime, and that was with a battery-powered mouse. Granted, this was at 4K, but it's still not impressive. This Blade needs to be plugged in. Still, we can't help but love it. It's expensive, but it combines the technical grunt of bulkier laptops with the clean design ethos of a premium ultrabook. **–CHRISTIAN GUYTON**

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,030	**1,237** (20%)
CrystalDisk QD32 Sequential Read (MB/s)	**3,374**	3,283 (-3%)
CrystalDisk QD32 Sequential Write (MB/s)	**2,530**	2,378 (-6%)
3DMark: Fire Strike (Index)	13,610	**17,320** (27%)
Rise of the Tomb Raider (fps)	92	**117** (27%)
Total War: Warhammer II (fps)	62	**81** (31%)
Tom Clancy's Ghost Recon: Wildlands (fps)	49	**65** (33%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Best scores in bold. Our gaming laptop zero-point is the Acer Predator Triton 500, with an Intel Core i7-8750H, Nvidia GeForce RTX 2060 Max-Q, and 16GB of DDR4-2666. All game tests are performed at 1080p at the highest graphical profile.

VERDICT 9

Razer Blade Pro 17 4K

CLEAN CUT Desktop-killing performance; vibrant 4K display; great connectivity.

HAND SAW Not so portable; that price really hurts.

$3,800, razer.com

SPECIFICATIONS

CPU	Intel Core i7-10875H
Graphics	Nvidia GeForce RTX 2080 Super Max-Q
RAM	16GB DDR4
Screen	17.3-inch 4K Touch 120Hz
Storage	1TB M.2 NVMe SSD
Ports	1x USB 3.2 Type-C, 3x USB 3.2 Type-A, 1x Thunderbolt 3, UHS-III SD card reader 1x HDMI 2.0, 1 x 3.5mm audio jack, 1x 2.5Gb Ethernet
Connectivity	Intel Wireless-AX201 (802.11a/b/g/n/ac/ax), Bluetooth 5.1
Weight	6.06lbs
Size	0.8 x 10.2 x 15.6 inches

LG UltraGear 34GN850

LG's new 160Hz, 1ms IPS ultrawide wonder

WE KNOW WHAT you're thinking: $1,000 for a 34-inch ultrawide 1440p monitor? And it doesn't even have local dimming? At least, that's what first struck us about the new LG UltraGear 34GN850. It ticks an awful lot of boxes, which you'd expect at this price point. But surely that much money buys you proper HDR support?

Hold that thought for a moment while we consider what the LG UltraGear 34GN850 does give you. First up there's 160Hz refresh. That's enough for the vast majority of semi-pro esports aficionados. It ties in neatly with the claimed 1ms response of the LG's Nano IPS panel. LG is one of the few monitor makers that actually produces LCD panels. In fact, it's the world's leader in IPS production, and thus has the pick of the latest and greatest of its own panels.

Long story short, LG reckons its new Nano IPS tech is comparable to TN panels for pixel response, while maintaining all the usual IPS advantages, such as superior color accuracy and viewing angles. That's critical, because there's little point in driving a display at triple-digit refresh rates if the panel's response rate can't keep up.

To the high refresh rate and low response times you can also add comprehensive adaptive sync support. Both Nvidia G-Sync and AMD FreeSync Premium are included. Note that the G-Sync support is G-Sync Compatible Verified rather than full-fat G-Sync, so it lacks Nvidia's processing chipset. However, overall the UltraGear 34GN850 packs a comprehensive, gaming-centric feature set.

Which brings us, at last, to what the 34GN850 doesn't give you—namely true HDR support. It does have VESA DisplayHDR400 certification. But that's the very lowest rung of HDR capability. DisplayHDR400 only demands 400cd/m2 of brightness (a requirement the 34GN850 meets but doesn't exceed) and does not stipulate local dimming, with which LG has indeed not bothered. Pair that with an IPS panel rated at 1,000:1 for contrast, and you hardly have the makings of a bona fide HDR experience.

While we're listing omissions, LG hasn't seen fit to include USB Type-C connectivity either. Consequently, you can't hook up a laptop and drive the display, charge, or connect peripherals with a single cable. The remit here is clearly gaming, the assumption arguably being that most buyers will be running desktops. But USB-C is such a flexible, powerful interface, it would still be a welcome inclusion, especially at this price point.

Anyway, if that's how the LG UltraGear 34GN850 stacks up in theory, what's it like in practice? Actually, darn nice.

Contrary to the 1,000:1 contrast and mere DisplayHDR400 ratings, this is a very punchy, vibrant display.

It's not perfect, of course. Notably, there's a little glow around bright objects set in dark backgrounds. HDR content and games simply don't have the eye-popping impact that a true HDR panel with local dimming and much higher brightness delivers. Then there's pixel response. Is it the fastest IPS panel we've seen? Almost certainly, yes. Can it match the best TN monitors for response? Just as surely, no.

But let's be clear. This is a fabulous all-round gaming monitor. It's quick enough for all but the most demanding esports players. If you have the graphics hardware to drive it properly, buttery smoothness awaits thanks to the 160Hz refresh. Moreover, the 34GN850 looks plain luscious in old-school adventure games like *Witcher 3*. And it's big enough and detailed enough to do justice to the more cinematic elements of strategy titles, such as the *Total War* series.

All of which means our main reservation involves pricing. This is a very sweet gaming monitor. But is it a $1,000 experience? Certainly, you can have 4K with high refresh for the same money, albeit in a smaller 27-inch form factor. Likewise, at this price point, DisplayHDR600 with local dimming would seem like a reasonable minimum expectation when it comes to HDR support. As it is, this is still a fantastic display. We're just not sure it's great value. **–JEREMY LAIRD**

The UltraGear 34GN850 packs LG's TN-rivalling 1ms Nano IPS panel tech.

VERDICT **8**

LG UltraGear 34GN850

OSCAR WINNER Great all-round gaming experience; very fast for an IPS monitor.

STRAIGHT TO STREAMING Awfully expensive; not a true HDR experience; no USB-C.

$995, www.lg.com

SPECIFICATIONS

Panel Size	34-inch
Panel Type	NanoIPS
Native Resolution	3,440 x 1,440
Brightness	400cd/m2
Contrast	1,000:1
Response	1ms
Colour Space	98% of DCI-P3
HDR Support	VESA DisplayHDR400
Inputs	DisplayPort, 2x HDMI, USB 3.1 hub
VESA mount	100 x 100mm
Other	Nvidia G-SYNC Compatible, AMD FreeSync Premium

Elgato Wave:3

Elgato fleshes out its streaming range with a great USB mic

SINCE CORSAIR ACQUIRED the Elgato brand back in 2018 (yikes, that feels like a long time ago now), it's been slowly expanding the options for would-be streamers. We imagine trade has been strong recently, as more people have sought to make some cash while confined to their homes as a pandemic ravaged the outside world. Starting with Elgato's original selection of docks and capture cards, Corsair expanded into streaming decks, lighting, and even green screens. The Wave:3—one of Elgato's two shiny new microphones—was the next logical step.

Yes, that's how it's stylized. Not the Wave 3, or the Wave: 3. This microphone has demanded that we repeatedly print the :3 emoji all over this page of *Maximum PC*, and we're furious about it. But weird punctuation aside, this is a serious addition to Elgato's streamer-centric selection, whether you're an aspiring Twitch gamer or an educational talk streamer.

We wouldn't exactly call it revolutionary, as it should be immediately familiar to anyone who has used a similarly high-end USB mic, such as the venerable Blue Yeti X. Still, the Wave:3 (ugh) is no slouch. 24-bit audio, a 96kHz sample rate, and a built-in pop shield mean that this USB-C mic is a viable option for those who take their streaming audio seriously. Elgato teamed up with Austrian audio professionals Lewitt Audio to build this mic, and it shows. In practice, voice recording comes out extremely clear, even when played over game audio. It picks up deep and high vocal pitches well, but what really brings the audio into next-level quality is this mic's secret weapon: Clipguard.

Clipguard is a built-in limiter and compressor that keeps recorded audio from peaking no matter the circumstances. Even actively shouting into the mic at point-blank range resulted in a coherent recording (if not a very pleasant one). It's very difficult to make your recorded audio distort with high volumes, and combining Clipguard with the concealed pop filter inside the body of the mic gives great-quality vocal recording. It's not the absolute best we've heard, but it's certainly up there.

The design of the Wave:3 (and its little brother, the more affordable Wave:1) is pleasingly minimalist. Pale white LEDs adorn the front of this mic's compact black casing, with a simple button dial and a capacitive mute button on the very top of the mic, allowing you to quickly mute yourself with a gentle tap. Clicking the dial enables you to swap between gain, volume, and chat mix for quick adjustments, but for more in-depth tweaking you'll want to use Elgato's Wave Link software.

SIMPLY GOOD

Wave Link isn't especially complex, and it's designed for use primarily by gaming streamers. It's easy to use but still packs plenty of useful features; tweaking the software to better suit your own range of speech will give you slightly better performance than simply using the defaults. There's a wealth of settings to mess about with here, allowing you to individually tune different volumes, connect multiple mics on the same network, or activate background noise-damping.

The Wave:3 comes with a simple metal stand (which works fine), but it can also be attached to your boom arm of choice via its universal bracket. A shock mount and external pop shield are sold separately, but the latter feels a bit redundant given the quality of the built-in pop filter. Really, the default stand does the job if you have the space on your desk for it; it tilts smoothly, and the rubberized underside keeps it firmly in place atop any surface.

The main downside here is that the Wave:3 only has one polar pattern: A cardioid field that only picks up sound directly in front of the microphone. This means that while the Wave:3 picks up sound from a single person exceptionally well, multiple speakers won't be picked up to nearly the same standard.

It's a shame, given the relatively high price, but it does make sense when considering that Elgato strongly leans towards supporting gaming streamers. So for a solo gamer sitting in front of a greenscreen, it's almost perfect.

–CHRISTIAN GUYTON

VERDICT **8**

Elgato Wave:3

SAY HELLO Excellent sound quality; digital mixing; compact but robust.

WAVE GOODBYE Not super versatile; only good for solo use.

$160, elgato.com

SPECIFICATIONS

Frequency Response	70Hz-20kH
Sample/Bitrate	96kHz/24-bit
Cable Length	2.5m
Polar Patterns	Cardioid
Element	Electret Condenser
Power Consumption	5V 500mA

HyperX Pulsefire Raid

A great sensor, 11 buttons, and a reasonable price, so what's the catch?

HYPERX IS NO STRANGER to the peripheral scene. Its Cloud range made a huge impact in the headset sector, and its keyboards have been solid too. Most recently, however, mice have become the company's focus.

The Pulsefire Raid is the latest mouse from HyperX. It has a mighty 11 buttons, nine of which are fully programmable, while the LMB and RMB can only be swapped between themselves. There are five thumb buttons, four of which are in the usual place above where your thumb naturally rests, and one further forward towards the end of your thumb, seemingly in Narnia for smaller handed users. The scroll wheel has movement to the left and right, as well as being able to click down, and a button directly behind the wheel defaults as a CPI adjustment button. While using any grip, the size of your hands (particularly your thumbs) will determine if you are able to reach the furthest forward of the five thumb buttons. This button is set to mute audio by default, and it is a really clever way of making the otherwise useless button something we came to like really quickly. Sure, it's pointless in-game, but a quick mute button on your mouse is not to be sniffed at, especially when there are 10 other buttons to use.

Despite the out-of-reach button, the Raid is a comfortable mouse to hold. Your thumb rests nicely on soft textured rubber, as does your ring finger and little finger. The back of the mouse has a rather aggressive slope but it still works well with palm and claw grips. The shape of this mouse is a little strange. There is no lip around the top of the mouse–as you would find on most mice—to help reposition the mouse at low CPI. Usually, your fingers are in a groove, but with the Raid the incline continues all the way to the top of the mouse, somewhat like trying to grip a smooth triangle. We found that when lifting the mouse off the mousepad it often slipped, so you have to reposition your hand again afterwards. This was particularly noticeable when using it in a fingertip grip. This is something that you would likely become accustomed to if you used it regularly, and it is only really noticeable when you're using the mouse at low DPI to gain more table surface area, so it isn't a huge issue.

GOOD TRACKING

Equipped with a Pixart 3389 sensor, the Pulsefire Raid tracks very well. This sensor trades blows with the Pixart 336x series and has no problems on any of the usual gaming surfaces. You have a lot of control over the sensitivity of the mouse as it can be programmed to run anywhere from 200CPI to 16,000CPI, with 50CPI increments. More usually with the 336x range, you are limited to 100CPI increments.

The CPI changes can be done in the NGenuity software, and it also has quite a substantial button-programming section. The software is in beta stages, and this is very apparent. Using it is clunky and far less intuitive than most other mouse software we've used. We also had to restart our system multiple times to get it working as intended. The less said about the software the better, but without the software you can only save one profile to the mouse.

Overall, the Pulsefire Raid is a great option for those who want a whole host of buttons but don't want a bulky MOBA mouse. The 11 buttons are very useful in games, and the sensor is up to the task of ensuring that any bad gameplay fails are down to you. The software leaves a bit of a bad taste in the mouth, but we imagine HyperX is working on this; it is still in the beta stage, after all. For the price you can't go far wrong, but if you would prefer fewer buttons, or if you can spend a little bit more, there are better options on the market. **–DAVE ALCOCK**

VERDICT **7**

HyperX Pulsefire Raid

HYPER FLEX Comfortable; majority of buttons easy to reach; great sensor; tightly woven sleeved cable.

HYPER WRECKED Poor software; limited RGB options; due to the shape you have to reposition the hand quite often.

$59.99 www.hyperxgaming.com

SPECIFICATIONS

Sensor	Pixart PMW3389 Optical
Max Sensitivity	16,000 CPI
Polling Rate	1000Hz
Programmable Buttons	11
Weight (with cable)	4.4oz
IPS	450
Switches	Omron
Connection Standard	Sleeved USB Cable

Return to Union City to take down the fake Utopia.

CYBERPUNK INDIE ADVENTURE

Beyond a Steel Sky

One of the great '90s adventures reimagined

ANYONE WHO'S BEEN playing PC games for 26 years will have come across *Beneath a Steel Sky*, the cyberpunk adventure from 1994 that set the scene for so much that came after it. At the peak of mid-'90s puzzling, *Beneath* had a wise-cracking robot, a totalitarian regime, and much to say about divisions in society.

That a sequel should come along after so much time had passed is unexpected, but certainly not unwelcome. It's come with some upgrades too—an Unreal 4 makeover that allows Dave Gibbons's comic book art to really shine, and the change from point-n-click to WASD controls is the right decision, but what's really surprising is how fresh and relevant this return to Union City is.

Robert Foster is from the Gap, the red Australian desert outside the few remaining super cities. Earth has undergone an unspecified disaster, and all those not inside a city are looked upon as savages. In reality, they might be the sensible people, because Union City, although ostensibly run by the benign Council, is a nest of problems.

First of all there's its structure: The city's towers are divided by social class, with industry and recycling banished to the tops of the towers while the lower levels are the domain of day spas, aspiration parties, and bars that serve only the local soda, called "Spankles." People wander around with fixed grins on their faces, which is no wonder, as they're constantly being monitored. A system known as "Qdos" assigns value to their actions, such as turning up for work and taking part in daily voting, and their social standing is calculated from the results.

Foster, who has returned to the city he left 26 years ago on the trail of some missing children, soon sets himself up with a counterfeit ID and a hacking device, and begins taking the system down from the inside by manipulating electronic information and the people he meets. Between trips to cyberspace he discovers the monstrous truth behind all the smiles, and the crimes of those in charge who are determined to keep things "happy."

Despite being deep in the shadow of the 1994 game—to the extent of having a museum dedicated to the world it depicted and sly references buried in its dialog trees—*Beyond* manages to find enough originality to break out of the darkness. Tearing down an outwardly utopian society turns out to be just as much fun as it was to set one up in the previous game, and for a game with no combat and very few opportunities to die, the stakes feel high enough to matter.

Puzzles rarely step over into impossible obscurity, although there's one at the beginning that will have many reaching for the comprehensive hint system. Near the end of the game they branch into the mathematical, particularly in the way you subvert the Qdos system, but you spend much of the game examining photos, locating toys, blowing up signs, and hiding from homicidal droids.

Returning to Union City after so much time away could have been a difficult marriage between ancient game design and modern gamers, but *Beyond* is instead a joyous experience, an adventure game tailor-made for 2020. **–IAN EVENDEN**

VERDICT 8

Beyond a Steel Sky

COSMOPOLITAN Future-set adventure with plenty of investigation and sneering bad guys.

OLD FASHIONED Some obscure puzzles; has some bugs to fix; occasional obvious lapses in logic.

RECOMMENDED SPECS CPU, i5 3470 / FX-8350. RAM, 6GB. GPU, GTX 970 / R9 280X.

$35, https://revolution.co.uk, not rated.

© REVOLUTION SOFTWARE LTD

Plot your way to the next city through the treacherous terrain.

Connect US cities from east to west by delivering cargo.

Norman Reedus heads up a host of recognizable in-game faces.

Soak up the wild, varied landscapes as you stumble from place to place.

WALKING SIM

Death Stranding

Life's a beach and then you don't die

"DO AS I SAY, and it will all make sense," says Guillermo Del Toro's character near the beginning of *Death Stranding*. That might as well be game director Hideo Kojima talking directly to the player, because, as with much of the *Metal Gear Solid* creator's latest title, little does make sense. Even if you do as he says.

Set in a post-apocalyptic world, *Death Stranding* at least has a unique apocalypse. The worlds of the living and the dead became connected, rain began making things age (known as "timefall"), and invisible ghosts now wander the landscape, violently exploding any living people they touch. What remains of humanity has retreated underground, but the cities have become disconnected. Your job is to wander roughly from east to west across the US, delivering cargo to cities, connecting them to a "chiral network" that'll magically solve everything, and avoiding the explodey ghosts (BTs), human terrorists (MULEs), and weirder things.

The cast, featuring captured performances from Norman Reedus, Lindsay Wagner, and Mads Mikkelson, in addition to Del Toro and others, makes for a remarkable-looking game, as does the reimagining of the US as a broadly green and gray environment, slick with rain and filled with snow-capped mountains, waterfalls, wide, empty plains, and dense forests. Despite some excellent ruined cities, this is the America of the hiker or the hunter, always keen to offer up a cave as shelter from the timefall, while also not afraid to throw deer off cliffs in their haste to escape from the BTs.

Lead character Sam Bridges (Reedus) is a porter for an organization called Bridges (go figure) whose job is to walk and deliver cargo. Sometimes he picks up extra cargo on his way, lost by previous expeditions, to the delight of those he delivers it to, but mostly he walks, staggers, slips, climbs, and keeps himself upright while wading through torrential rivers. His journeys are enormously detailed, the game as keen to show every effect of the rocks beneath his feet as it is to put his face front and center, filling your screen with his marked skin and scrubby facial hair. He's immortal, and can sense BTs in conjunction with a baby strapped to his chest—and that's not the weirdest thing he comes across.

A stamina system determines how long he can put up with the effects of the environment, and overloading him with cargo will make it harder for him to recover when a sharp turn pulls him sideways. Grip, which makes him hang on to his pack straps, can be applied to stop him falling over, but a fall—along with spending too much time in the timefall—will damage his cargo, reducing the rating he receives when it's delivered.

Death Stranding, with its long cutscenes, unintelligible technobabble, and characters that span a range from the creepy to the semi-normal to the deeply weird, is unmistakably a Kojima game, and one we're glad to see make its way to PC. There's a lot to take in, but it's at its best when you're left on your own to explore the glorious landscapes and the way Sam shimmies around cliff edges, making the long trek to get there worthwhile. **–IAN EVENDEN**

VERDICT 8

Death Stranding

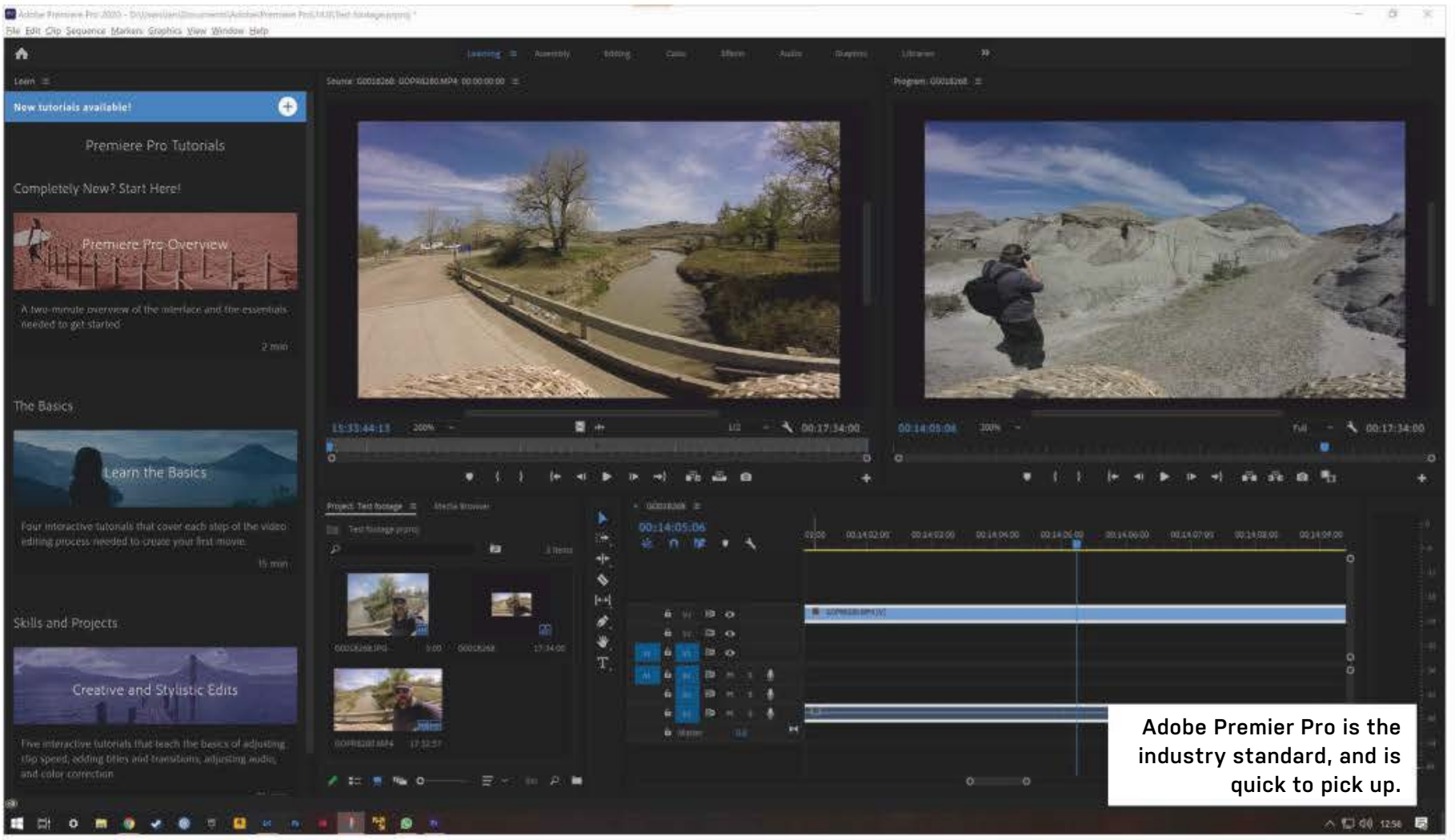
BEACHED Excellent performance; great to look at; compelling weirdness.

BREACHED You're a delivery boy; Kojima games are something of an acquired taste.

RECOMMENDED SPECS CPU, i7-3770 or Ryzen 5 1600. RAM, 8GB. GPU, GTX 1060 6GB or Radeon RX 590.

$60, kojimaproductions.jp/en, rated M

© 505 GAMES


Now tutorials available!
Premiere Pro Tutorials
Completely New? Start Here!
Premiere Pro Overview
A two-minute overview of the interface and the essentials needed to get started
2 min
The Basics
Learn the Basics
Four interactive tutorials that cover each step of the video editing process needed to create your first movie.
15 min
Skills and Projects
Creative and Stylistic Edits
Five interactive tutorials that teach the basics of adjusting clip speed, adding titles and transitions, adjusting audio, and color correction

Adobe Premier Pro is the industry standard, and is quick to pick up.

Premiere Pro vs DaVinci Resolve

Choose your champion in the battle of the big video-editing apps

TWO GREAT TITANS enter the arena. Only one will leave triumphant. These kinds of multi-camera, effects-laden scenes are precisely what Adobe's Premiere Pro and Blackmagic Design's DaVinci Resolve were designed to cope with, and it also neatly describes the battle between pro-level non-linear video editing apps. There must be a word for that.

There's room in this arena for both contenders, however. Nobody has to get hurt. In the red corner we find Premiere Pro, the shinobi from Adobe, famous for work such as *Deadpool*, *Terminator: Dark Fate*, and *Sharknado 2: The Second One*. Meanwhile, in the blue corner sits Australia's finest, DaVinci Resolve, fresh from working on *Deadpool 2*, *The Last Jedi*, and 35 films at the 2019 Sundance Film Festival you've never heard of.

This month we're comparing non-linear video editors. This is a type of editing in which the original footage isn't altered in any way. Edits are kept in the form of companion files generated by specialized software, and on playback the edited video is recreated from a combination of these files and the original source files. This means that the finished movie must be exported as a new file in order to share it or play it back on a different device. It sounds complex, but it's the way most video-editing apps work. You'll need a fast PC, a high-resolution monitor, and a large amount of fast storage to work effectively this way.

The big news about DaVinci Resolve, which is owned by mind-blowingly expensive camera company Blackmagic Design, is that there's a free version that contains 90 percent of the Studio version. All that's missing is support for resolutions above 4K and frame rates above 60fps, support for multi-GPU systems, some advanced machine learning, HDR, and stereoscopic video tools. Were you thinking of making an 8K 120fps 3D HDR movie? Then you'll need to part with $299.

For most people, the free version will suffice. It acts as a lure to interest potential customers in Blackmagic's $995 keyboard with dedicated edit keys and a jog wheel, or the $30,805 Advanced Panel that looks like part of the space shuttle. Video editing is a heck of a drug.

Resolve began life as a color-correction tool, but has since expanded into almost every corner of video production. Much like Serif's Affinity suite, it's broken up into "pages" that offer different functionality. A big new addition is the Cut page, which acts as a lighter version of the main edit suite, and is designed for quick cutting on location, likely on a portable PC with a small screen. It's more streamlined than the Edit page, which assumes you're using a larger screen and therefore provides more tools, but it's enough to hack together something in five minutes to show a client while your camera operator is packing up their gear.

Other pages in Resolve include Fusion, which deals with video effects and 3D compositing; and Fairlight, which is a complete digital audio workstation (DAW) with mixer, EQ, as well as dynamics processing, sound library support, and a lot more. Color correction is still there too, with the Color page dedicated to this subtle art. And finally, the Deliver page handles rendering and exporting, featuring presets for popular

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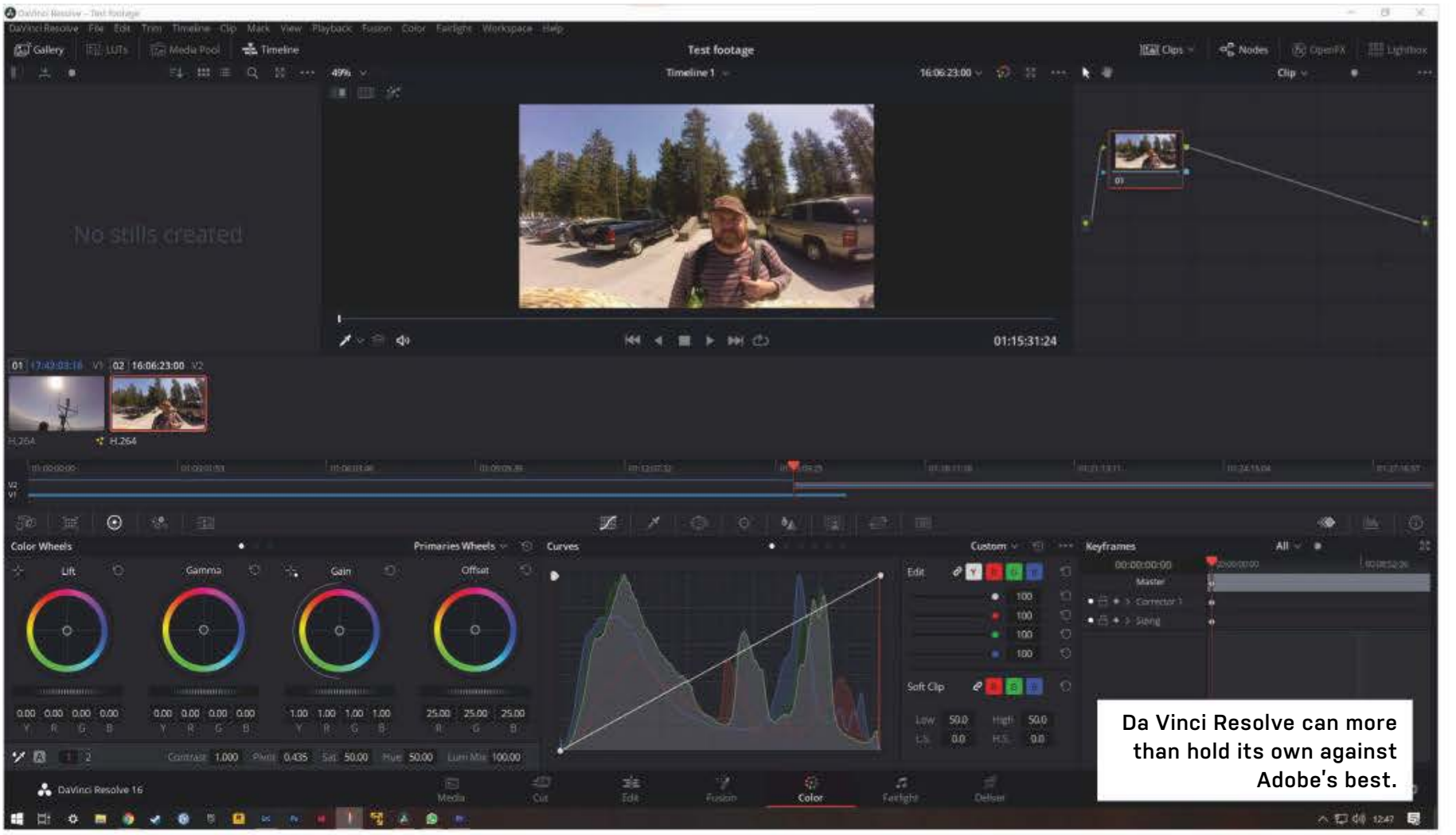

Da Vinci Resolve can more than hold its own against Adobe's best.

video-hosting sites, as well as having manual controls.

INDUSTRY STANDARD

Premiere Pro, on the other hand, is available through Adobe's Creative Cloud subscription scheme that we discussed last month. There's no free version, but a cut-down video-editing program is available for a fixed price in the form of Premiere Elements. This is a different app, however, which shares little more than its name with Premiere Pro, and shouldn't be confused with the main event. Premiere Rush also exists as part of Creative Cloud, bundled with Premiere Pro (with which its projects are compatible) or as its own subscription—this app is aimed at quick mobile-editing of videos exported straight to YouTube or similar sites, like Resolve's Cut page.

Premiere Pro itself has many features designed to speed up the process of video editing, although how useful they are depends entirely on the project you're working on and the style of editing you prefer. Premiere Pro's Assembly window lets you quickly splice clips together before taking them to the Edit window for fine-tuning, and there's color grading, effects integration, and audio editing just as you'd expect. Premiere is an app to take your time with, its Lumetri color-correction module operating more like Lightroom than Resolve's does. And while Blackmagic's app is an all-in-one solution, Adobe requires a separate subscription to After Effects if you want to add 3D or other motion graphics to your videos.

Adobe's products are the industry standard, and can be easier to grasp for beginners. Once you know the layout of one, you can find tools and palettes in many others, and this familiarity is a huge bonus for Premiere Pro. Many editors will want Photoshop installed on the same PC they use for video work, and the shared design language between the two apps goes a long way.

Resolve can more than hold its own against Premiere Pro, but sometimes using the standard app pays dividends for many professionals. Premiere Pro is on version 14, while Resolve is on version 16. These are mature applications that have been improved time and time again through feedback from industry professionals. The cost can be a large factor for those learning an application or working on personal projects, so Resolve's free version scores highly. A year's subscription to Premiere Pro costs twice what Resolve Studio costs as a one-off payment, and this, along with the Fusion and Fairlight pages, makes Resolve a very attractive proposition.

If you're just dabbling in video editing, Resolve is a no-brainer, as it's free. If you want to learn, Premiere Pro does have a learning mode, but consider Premiere Elements, which takes you through the process of non-linear editing in an approachable way and gives you transferable skills you can use in other apps. Both Premiere Pro and Resolve Studio are serious toys, and while it would be wrong not to recommend an app for that reason, there's so much pro functionality available for so little money elsewhere, we wonder why any home user would want them. –IAN EVENDEN

VERDICT 9

Premiere Pro

SPIELBERG Industry standard; easy to grasp; learning resources.

BAY Subscription pricing; it's not an all-in-one app.

RECOMMENDED SPECS Intel 7th gen or newer CPU or AMD equivalent, 32GB RAM for 4K, 4GB GPU VRAM.

$20.99 per month, www.adobe.com

VERDICT 9 KICK ASS!

DaVinci Resolve

HITCHCOCK All-in-one; free version is amazing; dedicated hardware available.

SMITHEE Enormously complex; less widely supported; hardware is expensive.

RECOMMENDED SPECS Intel Core i9 or AMD Ryzen 9, 32GB+ RAM, 8GB GPU VRAM

$FREE or $299, www.blackmagicdesign.com

© BLACKMAGIC DESIGN

LAB NOTES

ZAK STOREY, EDITOR

Looking to the Stars

From watching TV to gaming again (sort of)

LAST ISSUE I SPOKE about dropping the amount of gaming I was doing to just one day a week. I'm glad to say, I've actually managed to do it. Language learning is going well, and my future wife is happy I'm spending more time with her too.

We've been watching more TV together, particularly *The Expanse* on Amazon Prime. It is a very good, gritty space action drama set in the solar system, but it got me hankering for some good sci-fi gaming.

I've been a *Star Citizen* backer since 2017, but I've not really played it since then, as there wasn't much there. But I thought I'd give it a shot again. I jumped into Alpha 3.10, and oh boy have things changed.

There's multiple planets, moons, cities, mining, contracts, dogfighting, cargo-hauling, personal inventories, first-person shooting, inter-player trade, ground vehicles, all manner of environments, food and drink, health, co-op play, ship-purchasing—the list is endless. It's huge. It took me probably a week of on-and-off small sessions just to get to grips with it. That said, I am utterly in love. It's so much fun, bugs and all. I even got my best bud an account, and now he can't stop playing it either. Last night we picked up a contract to kill someone on a planet. I dropped down to the surface, landed my ship, and started approaching on foot to infiltrate the base. Suddenly ahead I hear all hell break loose. It's my bro firing like crazy overhead. The noise, the chaos, it was maddening. We jumped out, went inside and began dispatching the guards, before finishing off the contract and heading to the closest spaceport. So if you're a backer and haven't visited in a while, it's worth a shot.

Star Citizen's 3.10 patch is still fairly buggy, but there's so much to do now.

INDUSTRY INSIDER

Are gaming PCs finally in danger of being superseded by consoles? No, of course not: You can't buy a $6,000 home console, but the PlayStation 5 and Xbox Series X will be giving PCs a run for their money at the more affordable end of the scale. Recent claims state that the PS5 will be capable of running *Spider-Man: Miles Morales* at 4K 60fps (in "performance mode"), and the current pricing is believed to be $499 at the time of writing.

Building a PC that has any chance of matching that performance at the same price is virtually impossible. The custom AMD chips that both new consoles run on are incredible, and no component available to consumers can match its value. The PS5's graphical performance is expected to exceed that of the RX 5700 XT desktop GPU, which already costs around $400. Mouse and keyboard compatibility on next-gen consoles sweetens the deal.

Granted, consoles lack the flexibility of a PC. You can't make a Zoom call on your Nintendo Switch. But if you only use your $1,000 desktop PC for gaming and streaming your favorite entertainment media, a PS5 or Series X might suit you better. I know it's probably heresy to say such things here, but PC might have to fight to retain its gamers once the new consoles arrive.

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MacBook Woes and Headset Pros

LOGITECH G603

THERE'S A VAST ARRAY of IT systems we use to send every issue of *Maximum PC*. We use our in-house servers, Adobe's CC suite, and a bespoke piece of folio software called Future Studio. However, to access any of that, you need to have a company-issued corporate Mac device.

So I'm stuck with a MacBook. It's portable at least, and the build quality is nice, but it is frustrating to use. The trackpad is annoying, the keyboard is horrible, the screen is tiny, and I'm not even going to mention the OS.

I've wall-mounted an old 32-inch monitor, and have hooked that up to it using a USB-C to DisplayPort dongle. That's great for the screen, but I really wanted a normal mouse back as well, so I've been testing Logitech's G603 Lightspeed Wireless Gaming Mouse. It's about $70, but it has three big advantages: It can connect via Bluetooth; there's no RGB, so longer battery life; and it takes two AA batteries, so lasts up to 500 hours in low-power mode. It's also ergonomically comfortable, and gives me that coveted right-click again.

I've had problems with Bluetooth not reconnecting after the Mac goes to sleep, but it's been a perfect solution to my Apple woes during our WFH isolation. **–ZS**

$70, www.logitech.com

CORSAIR VIRTUOSO RGB WIRELESS

NEXT UP ON THE LIST of useful things I've had at home since lockdown began is this snazzy Virtuoso headset from Corsair. Now I am an absolute stickler when it comes to good-quality audio, and I hate wireless headphones. You just can't beat that 3.5mm jack for quality, and why the world has descended into mundane noise reproduction is beyond me.

When Corsair first announced its Virtuoso RGB Wireless headset I was in two minds about it, because it's marketed as a high-fidelity audio headset, and it's wireless. It packs in some impeccable 50mm 20Hz-40kHz drivers, a nice headphone distortion rating of 109dB, and your standard 32Ohms impedance too. It's also got a load of connection options—wireless 2.4GHz, USB, and analog 3.5mm, the latter two of which really gains the most from those expanded frequencies in the dynamic drivers, but the 2.4GHz and USB connections are the ones you want for any major EQ control. I've been using it predominantly as my work wireless headset, and it's been impressive. It's comfortable over long periods, looks nice, and the sound quality is on par with some of the best wireless headsets we've had using that 2.4GHz frequency.

It's useful for me, as I have a nine-foot-long desk, with two rigs on either end. It comes with a 20-hour battery life as standard, and you can set up Corsair's iCUE software so it shows headset battery life as an icon on your desktop. Audio is crisp, well-balanced, and with a reduced frequency response thanks to that wireless 2.4GHz connection—more than good enough for my day-to-day listening. **–ZS**

$160, www.corsair.com

EDITOR'S PICK

Christian Guyton,
Staff Writer

OPERA GAMING BROWSER

Just a few short days before I sat down to write this, freeware browser Opera opened the early access phase of its latest product: Opera GX, billed as the world's first "gaming browser." Yes, you read that right. Opera GX is a Chromium-based web browser, with a sleek, customizable design and all the bells and whistles that Opera includes. That means a free VPN, Chrome extension support, and a built-in ad blocker.

Then there's the gaming features, and I'll admit that I was intrigued. Discord and Twitch integration are unsurprising inclusions, but there's also WhatsApp, Instagram, and more. Opera GX goes deeper than that, too; the GX Control panel contains limiters for CPU, RAM, and network resources, enabling you to keep your browser from guzzling system resources while you're gaming. Smart tab-killer tools let you see exactly which open tabs are taking more than their fair share of resources, and the GX Corner includes news on free games and timed deals.

It doesn't really run better than regular Opera (which is to say, Chrome and Edge Chromium both feel a bit smoother to use), but it looks and sounds better. I never thought I'd want to turn up my browser's sound effects, but with sound design from the BAFTA-nominated band Berlinist, Opera GX genuinely does sound amazing.

There's something to be said for a browser that has been built from the ground up specifically for gaming. If you're not a gamer, I can't really recommend GX at all, but for any budding streamer or YouTuber, it's at the very least worth a look.

$FREE, www.opera.com

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LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> The Perfect $3K PC
> Conceptual Artistry
> Multiple 4K Streams

$3,000 Build Queries

First off let me say I am a huge fan of **MPC** as I have been reading for about four to five years. Now let me explain why I'm writing.

I am 27 years old and have been incarcerated in the MDOC since 2011. I say that to give you an idea of how much tech I have actually missed out on completely. Reading this mag is the only way I have been able to keep up with the times, even though I'm unable to experience it yet. Next August I am coming up for release and frankly, I am in need of some assistance.

I am looking to build a PC of my own that can handle intense gaming as well as streaming. I was strictly into MMOs, my go-to ones are *Runescape* and *World of Warcraft*, but I want to get into *CS:GO*, and *League* looks and sounds pretty epic.

For the rig, I wanted my budget, for just the tower, to be about $3,000 give or take. I don't really have a preference of Intel or AMD, but I'm not going to lie—AMD is looking like the future. I also couldn't really care less about RGB lighting, if you ask me it's a waste of time, money, and space. The easier the build the better, as this will be my first complete build, and I would love it to be as future-proof as possible.

I really appreciate your time, assistance, and everything you do to keep **MPC** in print, so fellow nerds, like myself, have something to look forward to every month. Even if my letter doesn't make it to print, I hope you could still find the time to reply and give me some advice, but if you ask me a $3,000(ish) gaming build based solely on performance instead of all that RGB crap would be interesting. Before closing, I would like to also thank everyone at **MPC**, because without all of you, I would still think my gateway is the bees knees.

PS. Could you also suggest a dual-monitor setup for said machine as well?

–Lucas Baade

EDITOR ZAK STOREY RESPONDS: Hi Lucas, thanks for writing in, so firstly just to answer the second part of your letter that we didn't include here (word counts are the bane of my existence) r.e. A physical address to write in to for comments, I just want to say I'm looking into it. Your letter did reach us, and quite quickly as well (took 11 days to reach my office) so writing to Future US, 11 West 42nd street, 15th Floor, New York, NY 10036, USA and dropping Maximum PC and my name in there somewhere does work.

I don't know if that's an official address we can use on a regular basis, it might just be a one-off. I'm going to chase that up with my line managers and see what the situation is, and then next issue, in comments and in the editor's intro, I'll also add a physical address as well for people like yourself who don't have access to the internet. We can incorporate that in somewhere in the page design on a permanent basis so everyone knows for the future.

As for your query, that's a good question. That's a lot of cash set aside for a rig, so you're definitely in a good place for that—especially if you want to get into streaming. I'd recommend an AMD Ryzen 9 3950X, Corsair iCUE H150i RGB Pro XT 360mm liquid cooler, Asus ROG Crosshair VIII Hero motherboard, 64GB (4x16GB) Corsair Vengeance LPX DDR4 @ 3200, 1TB Corsair Force MP600 PCIe 4.0 SSD (for your OS and games), 2TB WD Blue 2.5-inch SSD (for your recordings), an Nvidia GeForce RTX 2080 Super (or a 2070 Super, and plump for a bigger HDD), a Phanteks Evolv X ATX chassis, and an EVGA SuperNOVA G3 850W power supply. Right now that should bring you up to about $3,014 or so. I'd then pair that with two 27-inch Acer VG271U Pbmiipx monitors, they feature a 2560x1440 res at 144Hz, with a 1ms response on a VA panel, which will get you started in *CS:GO* if you want to go that way, although eventually you'll want a higher refresh than that, but for every other game they'd be perfect, and come in at $305 each: https://bit.ly/30ThPHI

One thing to point out: By the time you're released I imagine things will have changed a bit, as Ryzen's 4000 series should have launched, along with Nvidia's 3000-series cards. So your best bet is to get back in touch closer to the time on our Discord or here! We'll be happy to help out again then.

Concept Artist

Dear Sir, I would like to build a desktop PC for my daughter who is becoming a concept artist. I could just go out and

↘ submit your questions to: comments@maximumpc.com

buy a gaming system, but I'd rather put my money on a great build and have fun doing it. Would you have any recommendations on a past build that would point me in the right direction?

–Otis Campbell

EDITOR ZAK STOREY RESPONDS: This sounds like a really interesting project. I don't have a specific build that comes to mind, but there's a lot of similarities between that and the ITX system build we've done this very issue, and for one good reason. I actually do a lot of Photoshop design work in my own time. I started out my PC enthusiasm way back in the day through designing custom *World of Warcraft* UIs in 2007. I used to be known as Shiny Heart on wowinterface.com and built the Fundamental UI series. That's neither here nor there, but it's given me a good appreciation for the hardware requirements necessary to maintain that Photoshop hobby of mine. And I still dabble in it from time to time, although mostly building CVs for family and friends, and also photo manipulation.

For concept art in particular it's obviously significantly different to image manipulation and UI design, but a lot of the hardware requirements are the same. I'd recommend high-speed, high-capacity memory more than anything (I miss having 32GB). It doesn't matter too much what you go for processor-wise as long as it's at least a six-core, I'd say. Ideally you want six to 12 threads, and about 32GB of 3200MHz memory, and some really quick storage as well in the form of a PCIe SSD, and then a fairly decent GPU too—and by that I mean basically anything along the lines of a GTX 1650 or above. That'll make things really snappy and responsive. Perhaps something like this https://bit.ly/3iAduza inside of an NZXT H210 ITX chassis. That keeps it small and portable.

The bigger thing I'd recommend, especially for a concept artist, would be to really look into peripherals and a decent monitor as well. Wacom's Intuos Graphic Drawing Tablet is a fantastic solution for those looking to get into translating their physical artistic ability into the world of digital, and it's fairly cheap at about $80. It does take some time to adjust to, but I've heard good things from folks who've used them at Future. As for a monitor, a decent IPS screen would be a good choice, and there's a ton of flexibility with that. I'd recommend at least running a 27-inch 2560x1440 monitor. Refresh rate and response times don't really matter here, so you could pick up an Asus ProArt Display PA278QV for about $286 or so, although prices for a screen like that start at $220 anyway. It all depends on how much cash you have available really. Photoshop loves memory and quick storage though—always bear that in mind.

[NOW ONLINE]

THE ULTIMATE GUIDE TO BOOSTING WI-FI

Over the past few months, the internet has been a lifeline for us all, keeping us connected to each other, our places of work, friends and families.

However, nearly 70 percent of remote workers face technological challenges when working from home, according to Independence Research. Compounding that is the fact that M-Lab data indicates more than three-fourths of US states have actually seen slower internet speeds during the pandemic.

So, how can you maximize every ounce of internet you do have? Here are 19 handy ways to help improve your Wi-Fi connectivity.

Read the full article here: https://bit.ly/MPCWiFiBoost

Super Home Server

Hi Zak, I hope all is well. This is Kurt Kuhn, the guy who is looking to do a major upgrade for my personal server and PLEX. I have been doing this since 2000, using LaCie drives in the past, and now Drobo. I believe I have something like 92TB in operation of content, and still building with 4K now. Feel like 'spec'ing' out a system with me? Then recommending a builder?

My wife and I caught COVID-19 on July 5, and it has been a challenging month (some spent in the hospital), which is why I was delayed starting this process.

What do you believe the best processor would be to have multiple (maybe six) 4K streams happening at the same time? I am thinking of a Threadripper... What is the top dog these days?

–Kurt Kuhn

EDITOR ZAK STOREY AND THE DOC RESPOND: Hey Kurt, glad to hear you're on the mend! 92TB, wow that is a huge amount of storage, I imagine internet bandwidth is more likely to be the bottleneck than anything in that scenario, especially if you're not streaming locally. Usually high-performing single-core performance does better in transcoding and streaming tasks like that than more cores. Although I've got to admit that's an area that's outside of my zone of expertize, so I'll let The Doc chime in here.

The Doc's humble QNAP Ts-251+ can handle multiple streams easily if there's no transcoding involved—i.e., the devices streaming from the server can play the Doc's H264 streams directly. But let's assume transcoding will be involved—a good rule of thumb can found on this handy Plex page https://bit.ly/3fXYfyc that recommends a processor with a Passmark score of 12,000-17,000 for a single 4K stream (assuming it's being transcoded).

The key problem is potentially the networking bandwidth required to service four to six 4K streams at once. Streaming those over the internet would be challenging enough the Doc suspects —Netflix recommends a minimum of 25Mbps per stream, so first and foremost, are you streaming locally or over the net (like the Doc can with a maximum of two remote streams—neither HD though in this case, thanks to his crappy five to six Mbps broadband upload speeds)? But it may be an issue locally too. You'll need to look into whether a single (or even dual using link aggregation) 1Gbps Ethernet port is good enough, or whether you'd be better served upgrading to 10Gbps if most of those streams are staying local. Whatever happens, your server needs a direct line to the router—no wireless networking involved!

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THE BUILDS

SATA SSD STORAGE has never been cheaper. TeamGroup has further reduced the price of its GX1 2.5-inch drive, and we couldn't be happier about it: 120GB of SSD storage for under 20 bucks? A few years ago, that would've been impossible to find. Both budget builds have stuck with their drives this month, as the HDD kept its price and the SSD was cheaper. We've made changes elsewhere, though: A good deal on MSI's RX 5600 XT GPU saw us making the switch from ASRock's Challenger D model for our AMD machine, and we also swapped out the previous XPG memory for some fresh Z1 memory in bright gold, which was heavily discounted. Overall, we've made a modest saving on the AMD system.

The Intel build is a slightly different story. Our CPU rose in price by 10 bucks, and while we investigated the potential of upgrading to the 10600K, that would've meant throwing another $70 on top. The EVGA GPU we used last month is no longer on sale, so we've gone back to a twin-fan model—Asus's TUF Gaming factory-overclocked version—at the baseline 1660 Super price of $230. While the single-fan EVGA Super Black model was adequate, there's no reason to go down to a single fan unless it's significantly better value or you're building inside a super-compact case.

Thankfully, a slight price drop on the case, along with a fresh new motherboard and RAM for the Intel system, saved us enough money to keep the price below $800. The AMD system is now slightly cheaper, but allowing for general component price deviation, these two systems may as well share a price tag right now. Performance-wise, we won't see a huge amount of difference either. The RX 5600 XT slightly outperforms the GTX 1660 Super, but only by a small margin: Both excel at 1080p and are moderately capable at higher resolutions. On the other hand, the Ryzen chip falls just short of the i5-9600K in performance terms, but is cheaper and draws less power.

AMD INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	450W EVGA 450 BR	$53
Mobo	ASRock B550 Phantom Gaming 4	$115
CPU	AMD Ryzen 5 3600	$175
GPU	MSI Radeon RX 5600 XT 6GB NEW	$260
RAM	16GB (2 x 8GB) XPG Z1 Gaming Gold @ 3,000MT/s NEW	$55
SSD	120GB TeamGroup GX1 2.5" SATA III	$18
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15
Approximate Price:		**$786**

INTEL INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	$65
PSU	450W EVGA 450 BR	$50
Mobo	MSI Pro Z390-A NEW	$130
CPU	Intel Core i5-9600K	$200
GPU	Asus TUF Gaming GeForce GTX 1660 Super 6GB NEW	$230
RAM	16GB (2 x 8GB) GeiL Evo Spear @ 2,400MT/s NEW	$55
SSD	120GB TeamGroup GX1 2.5" SATA III	$18
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD	$30
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	$15
Approximate Price:		**$793**

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MID-RANGE

RIGHT OFF THE BAT, we saved ten bucks on both systems thanks to a discount on the Meshify C case from Fractal Design. We'd hoped to refresh all the cases earlier this year (and shoot them in our studio), but the specter of COVID-19 hanging over us precluded that from happening. It still will, though—hopefully soon!

PSU prices are on the move, and this month we've opted to give both mid-range systems the same power supply: The reliable Corsair CX650, which should provide more than enough juice. The Ryzen processor saw a slight price increase, while the i7-9700 dropped by $15. We took that and upgraded the Intel motherboard, sticking with MSI but opting for the slightly higher-end Z390 Gaming Plus model. The AMD build didn't warrant a new mobo, but we did swap out the GPU for ASRock's Radeon RX 5700, currently the best-value model of that card on the market. There are a few cheaper options available, sure, but we're not downgrading to a single-fan GPU for anything less than a $20 saving.

Really, there wasn't much else to change in the AMD build this month. A few handy price drops here and there were a welcome sight, and the Corsair Force MP600 SSD remains the best-priced 500GB drive that supports PCIe 4.0 transfer speeds.

We had more work to do on the Intel system; saving ourselves a few bucks by swapping to a different dual-fan air cooler was a start, but we were curious about upgrading the SSD too. Upon inspection, however, we found that the 500GB WD Black SN750 benefitted from an even bigger discount, now costing just $63 for half a terabyte of speedy M.2 storage. For reference, that's the version of the SN750 that comes without a heatsink—you may want to spring for the more expensive heatsink-included version to reduce heat buildup, since the Z390 motherboard we're using doesn't have its own thermal solution for M.2 drives. The version with a heatsink is discounted too, though, at $80 down from $120.

AMD INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$75
PSU	650W Corsair CX650	NEW	$86
Mobo	Asus TUF Gaming X570-Plus		$165
CPU	Ryzen 7 3700X		$285
Cooler	Noctua NH-U12S		$65
GPU	ASRock Radeon RX 5700 Challenger D 8GB	NEW	$330
RAM	16GB (2 x 8GB) Corsair Vengeance LPX @ 3,200MT/s		$60
SSD	500GB Corsair Force MP600		$110
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD		$30
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $1,306

INTEL INGREDIENTS

PART			PRICE
Case	Fractal Design Meshify C		$75
PSU	650W Corsair CX650	NEW	$86
Mobo	MSI MPG Z390 Gaming Plus	NEW	$195
CPU	Intel Core i7-9700		$305
Cooler	Cooler Master Hyper 212X	NEW	$52
GPU	Gigabyte GeForce RTX 2060 OC 6GB		$320
RAM	16GB (2 x 8GB) G.Skill Ripjaws V Series @ 2,400MT/s		$56
SSD	500GB Western Digital WD Black SN750 M.2 PCIe SSD		$63
HDD	1TB Seagate Constellation ES ST1000NM0001 HDD		$30
OS	Windows 10 Home 64-bit OEM		$100

Approximate Price: $1,282

IT'S ANOTHER NEW PSU! Wait, no it isn't. We've replaced the Corsair RM850x with its white-painted counterpart, which is inexplicably more than 20 bucks cheaper than the regular model at the time of writing. Besides the pearly paint job, it's identical: A fully modular 850W power supply with 80+ Gold efficiency certification.

We still couldn't really justify an upgrade to a 3rd-generation Threadripper chip in our AMD build. We know this is a "Turbo" system, but the 16-core Ryzen 9 3950X is still a beast, and far cheaper. It also meant we could stick with the excellent X570 chipset for our motherboard, and this month we're rocking the Prime X570-Pro from Asus. We toyed with swapping out the RAM and SSD in our AMD build, but both components have seen small price drops since last issue, so we decided to leave them be.

Unfortunately, high-end graphics cards seem to be having stock problems right now—the sensibly priced ones, anyway. RTX 2080 Super cards are flying off the shelves, so if you see one up for a good price, snap it up fast. EVGA's KO Gaming model was the only one still available at a reasonable price point when we wrote this, so we've unified these two machines and given the Intel system that GPU as well. The Intel build also received a boost in the form of a bigger AIO cooler, the Cooler Master MasterLiquid ML360R ARGB, exchanging two 140mm fans for three 120mm ones instead. A small saving on the Corsair Vengeance RGB Pro memory encouraged us to leave it in place, but we did opt to replace the SSD, switching from Samsung to the US-developed Sabrent Rocket Q, which saved us 70 bucks. The performance likely won't be quite on par with the 970 Evo it's replacing, but the price difference is night and day, and the Rocket Q boasts top-tier consumer reviews.

Both of these PCs dropped in price this issue, but the Intel Turbo build has increased its lead over the AMD system in terms of value. The AMD system does benefit from PCIe 4.0 and more cores, though, so we'd say it's a fair fight.

AMD INGREDIENTS

PART		PRICE
Case	NZXT H710i	$170
PSU	850W Corsair RM850x White **NEW**	$155
Mobo	Asus Prime X570-Pro **NEW**	$280
CPU	AMD Ryzen 9 3950X	$700
Cooler	Corsair iCUE H115i RGB Pro XT 280mm	$140
GPU	EVGA GeForce RTX 2080 Super KO Gaming 8GB	$740
RAM	32GB (2 x 16GB) G.Skill TridentZ Neo @ 3600MT/s	$175
SSD	1TB Patriot Viper Gaming VP4100 M.2 PCIe SSD	$195
HDD	6TB Seagate BarraCuda ST6000DM003 HDD	$134
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $2,789

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H710i	$170
PSU	850W Corsair RM850x White **NEW**	$155
Mobo	Asus ROG Strix Z490-E Gaming	$300
CPU	Intel Core i9-10900K	$550
Cooler	Cooler Master MasterLiquid ML360R ARGB 360mm **NEW**	$142
GPU	EVGA GeForce RTX 2080 Super KO Gaming 8GB **NEW**	$740
RAM	32GB (2 x 16GB) Corsair Vengeance RGB Pro @ 2,666MT/s	$140
SSD	1TB Sabrent Rocket Q M.2 PCIe SSD **NEW**	$120
HDD	6TB Seagate BarraCuda ST6000DM003 HDD	$134
OS	Windows 10 Home 64-bit OEM	$100

Approximate Price: $2,551

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